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National Dioxin Study Tier 4 Combustion Sources: Final Test Report Site 8, Black Liquor Boiler BLB-C

Radian Corp., Research Triangle Park, NC

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Final Test Report — Site 8 Black Liquor Boiler BLB — C

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16. ABSTRACT

This report summarizes the results of a dioxin/furan emissions test of a black liquor recovery boiler equipped with a drybottom electrostatic precipitator for particulate emissions control. Black liquor recovery boilers are used at kraft pulp mills to produce process steam and to reclaim inorganic chemicals from spent wood pulping liquors. This dioxin/furan emissions test was conducted under Tier 4 of the National Dioxin Study. The primary objective of Tier 4 is to determine if various combustion sources are sources of dioxin and/or furan emissions. If any of the combustion sources are found to emit dioxin or furan, the secondary objective of Tier 4 is to quantify these emissions.

Black liquor recovery boilers are one of 8 combustion source categories that have been tested in the Tier 4 program. The tested black liquor boiler, hereafter referred to as Boiler BLB-C, was selected for this test after an initial information screening and a one-day pretest survey visit. Boiler BLB-C is considered representative of black liquor recovery boilers with dry bottom electrostatic precipitators. The amount of chloride present in the black liquor circuit at this site is considered intermediate to high relative to that found at other kraft pulp mills.

Data presented in the report include dioxin (tetra through octa homologue +2378 TCDD) and furan (tetra through octa homologue +2378 TCDF) results for both stack samples and ash samples. In addition, process data collected during sampling are also presented.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Air Emissions Combustion Sources Dioxin Furans 2,3,7,8 Tetrachlorodibenzo-p-dioxin Black Liquor Boiler Pulp and Paper	Air Pollution Emissions Data	

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NATIONAL DIOXIN STUDY
TIER 4 — COMBUSTION SOURCES

Final Test Report — Site 8
Black Liquor Boiler BLB — C

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FOREWORD

This report is the result of a cooperative effort between the Office of Research and Development's Hazardous Waste Engineering Research Laboratory (HWERL) and the Office of Air Quality Planning and Standard's Monitoring and Data Analysis Division (MDAD). The overall management of Tier 4 of the National Dioxin Study was the responsibility of MDAD. In addition, MDAD provided technical guidance for the source test covered by this report. HWERL was directly responsible for the management and technical direction of the source test.

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1.0 INTRODUCTION

This report summarizes the results of a dioxin/furan[a] emissions test of a black liquor recovery boiler equipped with a dry-bottom electrostatic precipitator for particulate emissions control. Black liquor recovery boilers are used at Kraft pulp mills to produce process steam and to reclaim inorganic chemicals from spent wood pulping liquors. This dioxin/furan emissions test was conducted under Tier 4 of the National Dioxin Study. The primary objective of Tier 4 is to determine if various combustion sources are sources of dioxin and/or furan emissions. If any of the combustion sources are found to emit dioxin or furan, the secondary objective of Tier 4 is to quantify these emissions.

Black liquor recovery boilers are one of 8 combustion source categories that have been tested in the Tier 4 program. The tested black liquor boiler, hereafter referred to as Boiler BLB-C, was selected for this test after an initial information screening and a one-day pretest survey visit. Boiler BLB-C is considered representative of black liquor recovery boilers with dry bottom electrostatic precipitators. The amount of chlorides present in the black liquor circuit at this site is considered intermediate to high relative to that found at other Kraft pulp mills.

This test report is organized as follows. A summary of test results and conclusions is provided in Section 2.0, followed by a detailed process description in Section 3.0. The source sampling and analysis plan is outlined in Section 4.0, and the dioxin test data are presented in Section 5.0. Sections 6.0 through 9.0 present various testing details. These include descriptions of the sampling locations and procedures (Section 6.0), descriptions of the analytical procedures (Section 7.0), and a summary of the quality assurance/quality control results (Section 8.0). The appendices contain data generated during the field sampling and analytical activities.

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[a] The term "dioxin/furan" as used in this report refers to the polychlorinated dibenzo-p-dioxin and dibenzofuran isomers with four or more chlorine atoms.

2.0 SUMMARY AND CONCLUSIONS

2.1 OVERVIEW OF THE TEST PROGRAM

The host plant (Site BLB-C) is a Kraft pulp mill that produces pulp and paper products. Black liquor recovery boiler BLB-C combusts concentrated spent liquor from the pulping process and recovers the inorganic chemicals used to produce pulp from wood chips. Particulate emissions from black liquor boiler BLB-C are controlled by a dry bottom electrostatic precipitator. A simplified process flow diagram of the system is shown in Figure 2-1.

The gaseous, liquid, and solid sampling performed during the test program are summarized in Table 2-1. Sampling for dioxin and furan was performed simultaneously at the electrostatic precipitator outlet exhaust stack and the electrostatic precipitator inlet location (i.e., black liquor boiler outlet) in each of a series of three test runs conducted on April 23 through 25, 1985. The dioxin/furan sampling followed the October 1984 draft of the Modified Method 5 (MM5) procedure developed by the American Society of Mechanical Engineers (ASME) for measuring emissions of chlorinated organic compounds. MM5 train components and train rinses were analyzed for dioxins and furans by EMSL-RTP and ECL-BSL, two of three EPA laboratories collectively known as Troika. Composite samples of electrostatic precipitator catch obtained for each test run were also analyzed for dioxins and furans by these laboratories. The dioxin/furan analysis of the MM5 sample train components and the precipitator catch samples quantified 2,3,7,8-TCDD and the tetra- through octa-dioxin/furan homologues present in the samples.

Dioxin/furan precursor analyses were performed on samples of the concentrated black liquor fed to the boiler. The specific dioxin precursors analyzed for were chlorophenols, chlorobenzenes, polychlorinated biphenyls, and total chlorine. Samples of black liquor circuit streams (weak black liquor, strong black liquor, and white liquor) and black liquor circuit input streams (vanillin black liquor, caustic, make-up water, and make-up lime) were taken and some of the samples were analyzed by Radian for total chlorine. The total chlorine analyses of these streams were used to characterize the black liquor circuit at Site BLB-C and to quantify the major chlorine inputs to the

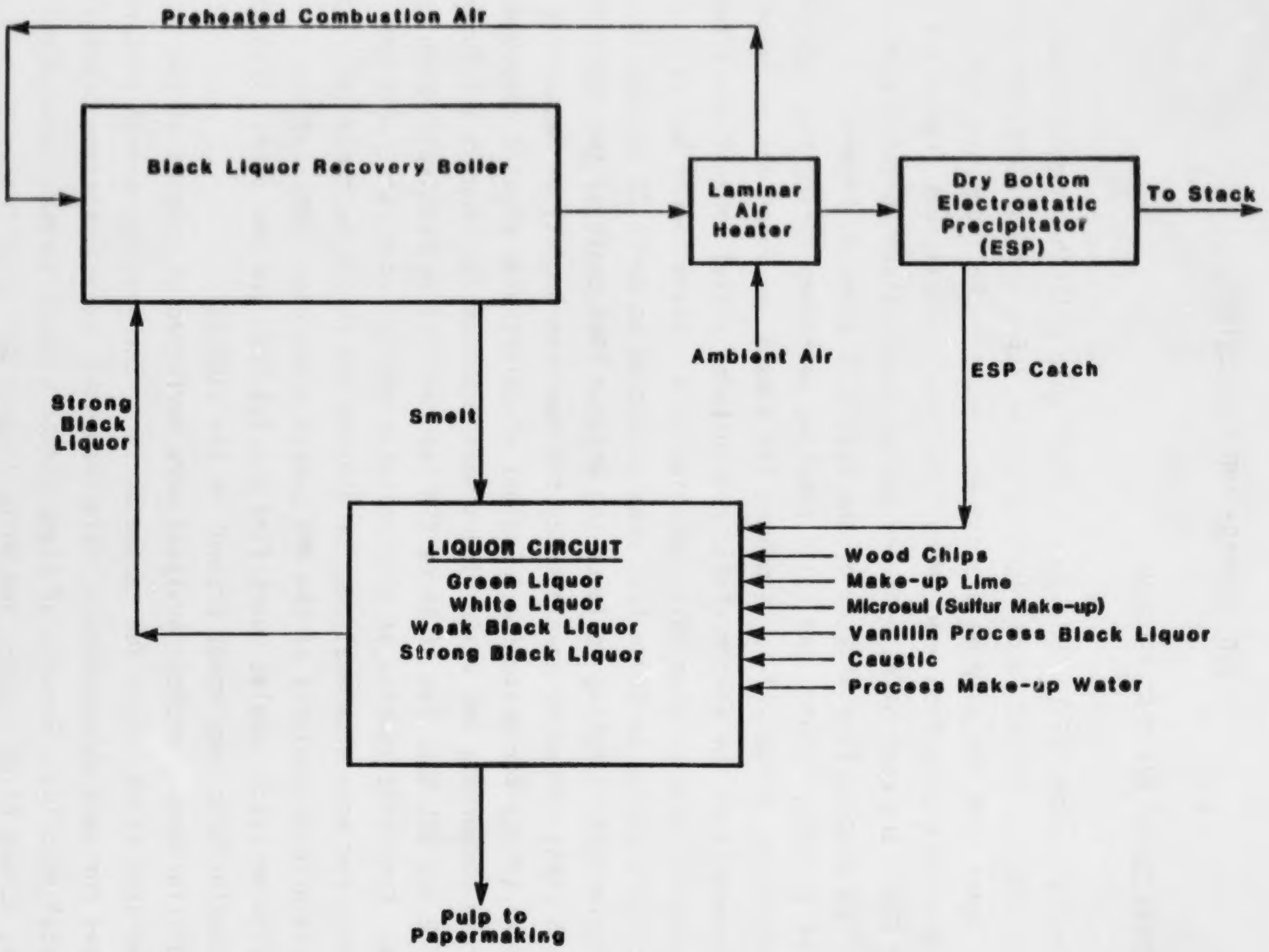

Preheated Combustion Air
Black Liquor Recovery Boiler
Laminar Air Heater
Dry Bottom Electrostatic Precipitator (ESP)
To Stack
Ambient Air
ESP Catch
Strong Black Liquor
Smelt
LIQUOR CIRCUIT
Green Liquor
White Liquor
Weak Black Liquor
Strong Black Liquor
Wood Chips
Make-up Lime
Microsul (Sulfur Make-up)
Vanillin Process Black Liquor
Caustic
Process Make-up Water
Pulp to Papermaking

Figure 2-1. Simplified Process Flow Diagram of Black Liquor Recovery Boiler System BLB-C

TABLE 2-1. SOURCE SAMPLING AND ANALYSIS OVERVIEW FOR SITE BLB-C

Item	Item Description
1. Number of test runs	- Three identical test runs. (Runs 1, 2, 3).
2. Gaseous Sampling	- MM5 sampling at electrostatic precipitator outlet stack (Runs 1, 2, 3). Dioxin/furan analysis.
	- MM5 sampling at electrostatic precipitator inlet (Runs 1, 2, 3). Dioxin/furan analysis.
	- EPA Reference Methods 2 and 4 at electrostatic precipitator inlet and outlet (Runs 1, 2, 3). Gas velocity and moisture.
	- Integrated bag sampling at electrostatic precipitator inlet and outlet (Runs 1,2,3). CO_2, O_2, N_2 analysis for molecular weight determination.
	- HCl sampling at electrostatic precipitator outlet (Runs 1, 2, 3).
	- Continuous monitoring of CO, CO_2, O_2, SO_2, NO_x, and total hydrocarbons at electrostatic precipitator outlet. (Runs 1, 2, 3).
	- Ambient combustion air sampling (two composite samples for Runs 1, 2, 3). Potential dioxin/furan analysis, dioxin precursor analysis.
3. Liquid Sampling	- Strong black liquor sampling (Runs 1, 2, 3). Dioxin precursor analysis, total chlorine analysis.
	- Fuel oil sampling (Run 3 only) Dioxin/furan analysis, dioxin precursor analysis, total chlorine analysis.
	- Miscellaneous liquor circuit stream sampling (Runs 1, 2, 3). Total chlorine analysis.
4. Solids Sampling	- Electrostatic precipitator catch sampling (Runs 1, 2, 3). Dioxin/furan analysis.
	- Soil sampling (one composite sample from 10 locations). Potential dioxin analysis.

black liquor circuit. A single composite soil sample was also obtained, but analysis of this sample was deferred pending evaluation of the dioxin/furan emissions data.

Continuous emissions monitoring (CEM) was performed at the electrostatic precipitator outlet location for CO, CO_2, NO_x, SO_2, total hydrocarbons (THC), and O_2. The continuous monitoring data were used in conjunction with process data to document the stability of combustion conditions during the test. HCl train sampling was performed at the electrostatic precipitator outlet location to determine the emission rate of total chlorides from the precipitator.

2.2 SUMMARY OF RESULTS

The data obtained at Site BLB-C during the Tier 4 test program is summarized in Figure 2-2. Detectable quantities of all targeted dioxin and furan species except 2378 TCDD and 2378 TCDF were found in the stack gas at the outlet from the ESP. As shown in Table 2-2, average as-measured stack gas concentrations of the total PCDD and total PCDF at the ESP outlet were 2.3 ng/dscm and 1.1 ng/dscm, respectively. The hourly emission rates were 680 ug/hr for total PCDD and 330 ug/hr for total PCDF. Octa-CDD was the most prevalent of the tetra- through octa-chlorinated dioxin homologues, while the furans were fairly evenly distributed among the tetra- through octa-chlorinated furan homologues. The ESP appeared to have positive control for reducing dioxin/furan emissions although analytical uncertainties inherent in GC/MS analysis limited the ability to quantify the control efficiency accurately.

The flue gas samples at the ESP inlet were not analyzed specifically for the 2378 TCDD and 2378 TCDF homologues. Detectable quantities of PCDD and PCDF homologues were found in the inlet flue gas to the ESP. Average as-measured stack gas concentrations of total PCDD and total PCDF at the ESP inlet were 4.1 ng/dscm and 7.0 ng/dscm respectively. The hourly emission rates were 1060 ug/hr for total PCDD and 1810 ug/hr for total PCDF. The dioxins were fairly evenly distributed among the tetra- through octa-chlorinated dioxin homologues, while tetra-chlorinated furans were predominant among the furan homologues.

ESP Ash Ⓓ

Species	Concentration (ppb)
Total PCDD	0.02
Total PCDF	0.02

Liquor Circuit Inputs Ⓖ Ⓗ Ⓘ Ⓙ

Stream	Flowrate	Total chlorides Concentration (ppm, wet basis)	Average Mass Flowrate of Chloride (lb/hr)
Vanillin Black Liquor[a]	30 gpm	800	12.0
Microsul[b]	0.74 gpm	512	0.3
Make-up Lime	21 TPD	-	-
Fresh Water Make-up	1600 gpm	3	2.3

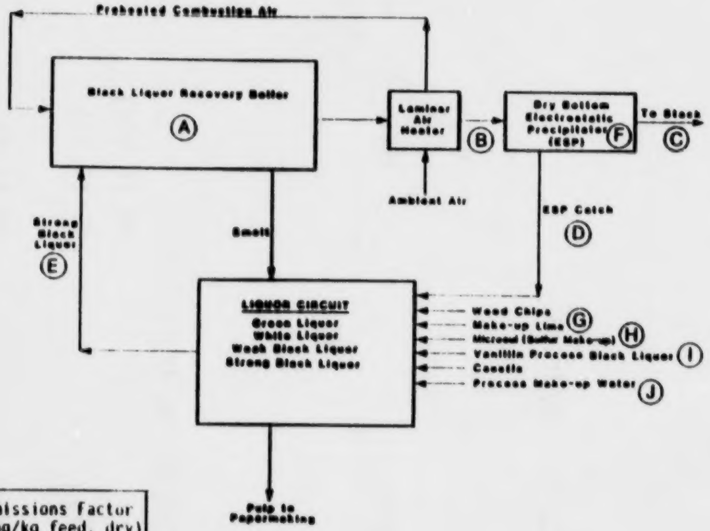
[a] Runs 1 and 2 only
[b] Run 3, only

Continuous Monitoring Data Ⓒ

O_2	12.2 %vol, dry
CO_2	17.0 %vol @ 3% O_2, dry
CO	863 ppmv @ 3% O_2, dry
THC	23.0 ppmv @ 3% O_2, wet
SO_2	80.3 ppmv @ 3% O_2, dry
NO_x	40.9 ppmv @ 3% O_2, dry

Black Liquor Boiler Operating Data Ⓐ

Feedrate	212 gpm
Operating hours	8,760 hrs/yr


Preheated Combustion Air
Black Liquor Recovery Boiler
Ⓐ
Laminar Air Heater
Ⓑ
Dry Bottom Electrostatic Precipitator (ESP)
Ⓕ
To Stack
Ⓒ
Ambient Air
ESP Catch
Ⓓ
Strong Black Liquor
Ⓔ
Smelt
LIQUOR CIRCUIT
Green Liquor
White Liquor
Wash Black Liquor
Strong Black Liquor
Wood Chips
Ⓖ
Make-up Lime
Ⓗ
Microsul (Sulfur Make-up)
Vanillin Process Black Liquor
Ⓘ
Caustic
Process Make-up Water
Ⓙ
Pulp to Papermaking

ESP Operating Data Ⓕ

Inlet temperature	156°C
Inlet gas flowrate:	
East duct	2,100 dscmm
West duct	2,600 dscmm
Total	4,700 dscmm

Black Liquor Feed Precursor Data Ⓔ

Chlorobenzenes	ND
PCB's	ND
Chlorophenols	trace
Total chlorides	3350 ppm

Dioxin/Furan Emissions Data

	Species	Concentration (ng/dscm @ 3% O_2)	Emission Rate (ug/hr)	Emissions Factor (ng/kg feed, dry)
Ⓑ	INLET:			
	2378 TCDD	NR	NR	NR
	Total PCDD	9.0	1060	25
	Total PCDF	15.1	1810	40
Ⓒ	OUTLET:			
	2378 TCDD	ND	ND	0
	Total PCDF	2.9	680	16
	Total PCDF	2.1	330	8

NR = not reported; ND = not detected.

Flue Gas Parameter Data

Ⓑ	INLET:	Flowrate	4,700 dscmm
		Temperature	155°C
		Moisture	19.3 vol%
Ⓒ	OUTLET:	Flowrate	4,900 dscmm
		Temperature	146°C
		Moisture	19.5 vol%

Chloride Emissions Data Ⓒ

Train Component	Concentration (mg/dscm @ 3%O_2)	Emission Rate (kg/hr)	Emission Factor (mg/kg feed, dry)
Front half	10.6	1.5	35
Back half	172.7	26.4	615
Train total	208.0	27.9	650

Figure 2-2. Data summary for Site BLB-C.

TABLE 2-2. SUMMARY OF MEAN DIOXIN AND FURAN EMISSIONS DATA FOR SITE BLB-C

Parameter	2378 TCDD[a]	Total PCDD	Total PCDF
INLET:			
Emissions Concentration (ng/dscm)			
As-measured	NR	4.1	7.0
Corrected to 3% O_2	NR	9.0	15.1
Emissions Rate (ug/hr)	NR	1,060	1,810
OUTLET:			
Emissions Concentration (ng/dscm)			
As-measured	ND (0.006)	2.3	1.1
Corrected to 3% O_2	ND (0.01)	2.9	2.1
Emissions Rate (ug/hr)	ND (1.6)	680	330

---

[a] Values in parenthesis are detection limits expressed in the corresponding units.

NR - not reported.

Dioxin and furan homologues were detected at low concentrations in the ESP ash. Only octa-CDD, octa-CDF and hepta-CDF were detected in these samples. The total PCDD and total PCDF concentrations were both 0.02 ppb which was near the minimum detection limit.

Chloride emissions at the ESP outlet were measured at 102 mg/dscm which corresponds to 208.0 ng/dscm @ 3% O_2. The average chlorides emission factor was calculated to be 650 mg chloride emitted per kilogram of black liquor fired on dry basis. The total chloride emissions were estimated to be 95% HCl.

The black liquor feed rate to Boiler BLB-C was 212 gpm during the test period. Precursor analysis of the black liquor did not detect chlorobenzenes or polychlorinated biphenyls. A trace amount of chlorophenols were detected, and the black liquor contained 3350 ppm of total chlorides. Of the liquor circuit inputs sampled, vanillin black liquor was determined to contribute the most chlorides to the liquor circuit.

The ESP treated an average of 4,700 dscmm at a temperature of 156°C. At the outlet stack, the measured flowrate was 4,900 dscmm at a temperature of 146°C. Average flue gas concentrations measured at the ESP outlet by the Radian continuous emissions monitoring system were: O_2, 12.2 vol%; CO_2, 17.0 vol% @ 3% O_2 (dry); CO, 863 ppmv @ 3% O_2; THC, 23.0 ppmv @ 3% O_2, wet; SO_2, 80.3 ppmv @ 3% O_2, dry, and NO_x, 40.9 ppmv @ 3% O_2, dry.

The composite soil sample for Site BLB-C has not yet been analyzed for dioxin/furan content.

SECTION 3.0
PROCESS DESCRIPTION

This section describes the host site and the black liquor recovery boiler/electrostatic precipitator system that was tested.

3.1 FACILITY DESCRIPTION

The host site is a typical Kraft pulp mill with a rated capacity of approximately 1150 tons per day (TPD) of air-dried pulp. A schematic diagram of the black liquor recovery circuit is shown in Figure 3-1. The plant maintains two black liquor recovery boilers that are rated at 500 and 850 TPD air dried pulp, respectively.

The 500 TPD boiler, designated by the plant as the No. 3 recovery boiler, was built in 1961 and uses a direct contact evaporator to perform the final solids concentrations of the strong black liquor fired in the boiler. The 850 TPD boiler is designated by the plant as the No. 4 recovery boiler. It is a low-odor boiler that was built in 1973. The No. 4 recovery boiler system was tested in this program.

3.2 BLACK LIQUOR RECOVERY BOILER DESCRIPTION

Boiler BLB-C is a low-odor Combustion Engineering recovery boiler with a rated capacity of 850 TPD of air dried pulp. The boiler was installed in 1973 and typically operates 7 days per week, 24 hours per day.

The black liquor circuit for Boiler BLB-C is common with that for the other recovery boiler at Site BLB-C from the point of weak liquor generation in the pulp mill until final solids concentration prior to combustion.

Wood chips fed to the pulp mill are obtained from a variety of sources. Some of the wood processed by the plant at any given time is likely to have been stored in salt water, but plant personnel could not estimate the fraction of salt-laden wood in the system. To the best knowledge of plant personnel, none of the wood had been treated with pentachlorophenol or other chlorinated wood preservatives.

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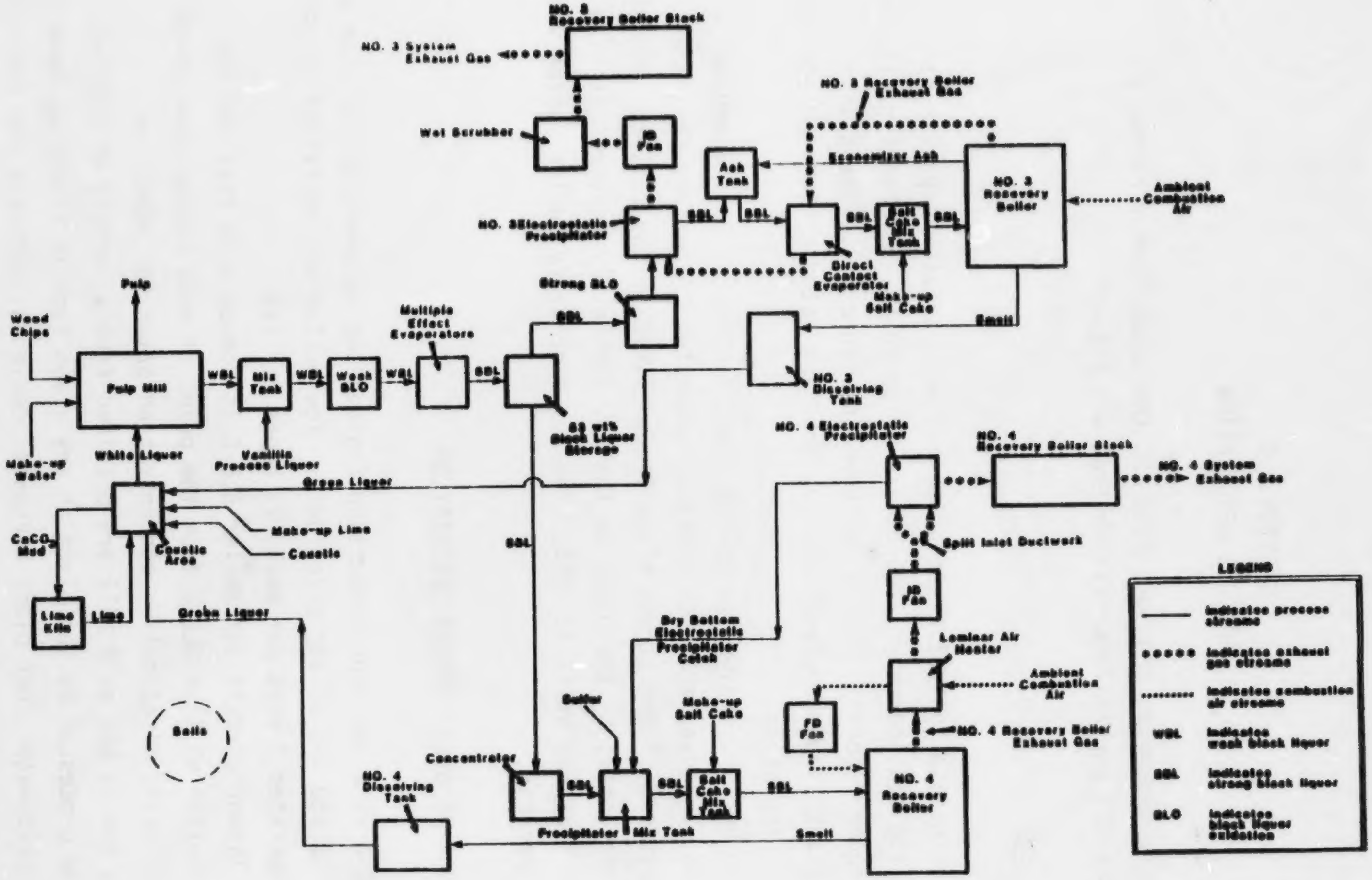
NO. 3 Recovery Boiler Stack
NO. 3 System Exhaust Gas
Wet Scrubber
ID Fan
NO. 3 Recovery Boiler Exhaust Gas
Ash Tank
Economizer Ash
NO. 3 Recovery Boiler
Ambient Combustion Air
NO. 3 Electrostatic Precipitator
SBL
Direct Contact Evaporator
Salt Cake Mix Tank
Make-up Salt Cake
Strong BLO
Smelt
Pulp
Wood Chips
Pulp Mill
WBL
Mix Tank
Wash BLO
Multiple Effect Evaporators
63 wt% Black Liquor Storage
NO. 3 Dissolving Tank
Make-up Water
White Liquor
Vanillin Process Liquor
Green Liquor
CaCO3 Mud
Caustic Area
Make-up Lime
Caustic
Lime Kiln
Lime
NO. 4 Electrostatic Precipitator
NO. 4 Recovery Boiler Stack
NO. 4 System Exhaust Gas
Split Inlet Ductwork
Dry Bottom Electrostatic Precipitator Catch
Laminar Air Heater
FD Fan
NO. 4 Recovery Boiler Exhaust Gas
Sulfur
Make-up Salt Cake
Concentrator
Precipitator Mix Tank
NO. 4 Recovery Boiler
NO. 4 Dissolving Tank
Smelt
Seals
LEGEND
indicates process streams
indicates exhaust gas streams
indicates combustion air streams
WBL indicates weak black liquor
SBL indicates strong black liquor
BLO indicates black liquor oxidation

Figure 3-1. Schematic Diagram of Black Liquor Recovery Boiler System BLB-C

Weak black liquor produced by the pulp mill is first mixed with a byproduct stream (i.e., vanillin black liquor) purchased from a synthetic vanillin manufacturing plant. The primary feed material to the vanillin manufacturing plant is spent red liquor from a nearby sulfite pulp and paper mill. The vanillin black liquor by-product provides make-up sodium and sulfur to the black liquor circuit at Site BLB-C.

After addition of vanillin black liquor, the weak black liquor undergoes weak black liquor oxidation (BLO), which helps minimize total reduced sulfur (TRS) emissions from the recovery boilers. The oxidized liquor is then concentrated to approximately 53 wt% solids using a multiple effect evaporator system. As shown in Figure 3-1, the resulting 53 wt% liquor is further concentrated by one of two routes, depending on whether it is fired in the No. 3 or the No. 4 (BLB-C) recovery boiler system.

Liquor fired in Boiler BLB-C is concentrated to approximately 63 wt% solids using a two-stage concentrator. The strong black liquor is then mixed with captured particulate from the dry bottom electrostatic precipitator that controls emissions from Boiler BLB-C. A petroleum by-product known as Microsul is frequently added to the strong black liquor prior to firing in the boiler. The microsul serves primarily as a source of make-up sulfur. It is a viscous off-white liquid with an aromatic odor. The average total chloride content of the strong black liquor was measured at 3350 ppm (wet basis) during the test periods, which corresponds to 0.5 weight percent chloride on a dry solids basis. Based on a comparison of available black liquor chloride content data from other Kraft pulp mills, this is considered an intermediate to high value.

The major potential input sources of chlorine to the black liquor circuit are: salt contained in the wood chips fed to the pulp mill, vanillin black liquor, make-up water, make-up lime, and microsul. Most of the chlorine input to the black liquor circuit is in the form of inorganic chloride.

The rate of input for these materials during the test periods are shown in Table 3-1. Vanillin black liquor was added during Run 1 and Run 2, but microsul was substituted during Run 3. Caustic was not added during the test period. The chloride concentrations of the input materials except for the wood chips and make-up lime were analyzed and the results are presented in

TABLE 3-1. LIQUOR CIRCUIT INPUT MATERIALS DURING THE TEST RUNS AT SITE BLB-C

	Run 01	Run 02	Run 03
Wood Chips	NM	NM	NM
Vanillin Black Liquor	30 gpm	30 gpm	None
Microsul	None	None	0.74 gpm
Make-up Lime	21 TPD	21 TPD	21 TPD
Fresh Water Make-up	1370 gpm	1640 gpm	1770 gpm
Caustic	None	None	None

NM = not measured

Table 3-2. The results show that vanillin black liquor has the highest concentration of chlorides and added approximately 12 lb/hr of chlorides to the liquor circuit. During Run 3, microsul was substituted for the vanillin black liquor, which reduced the chlorides contribution from make-up sodium sources to approximately 0.3 lb/hr of chlorides.

Concentrated black liquor is fired in Boiler BLB-C through several oscillating liquor guns. The total black liquor flow rate to the guns ranges from about 0.7 to 1.0 cu meter/min (190 to 270 gpm), with an average of approximately 0.85 cu meter/min (230 gpm). The solids content of the liquor fired in the boiler is approximately 63 weight percent. Oil is fired as auxiliary fuel when the black liquor feed rate is less than about 0.8 cu meter/min (200 gpm).

The combustion air supplied to Boiler BLB-C is preheated to approximately 135^{0}C (275^{0}F) using laminar air heaters which exchange heat from the boiler exhaust gas. The laminar air heaters are located immediately upstream of the electrostatic precipitator inlet, and they introduce a considerable amount of ambient air inleakage into the boiler exhaust gas stream. Preheated combustion air from the laminar air heaters is supplied to the boiler through primary air nozzles and secondary air ports. The ratio of primary to secondary air is typically about 1:1.3. The total air supply is controlled using a Bailey Network 90 distributed control system. This system uses combustibles and oxygen monitoring at the boiler outlet location to control the combustion air supply to the boiler. The oxygen concentration at the boiler outlet ranges from about 1.9 to 3 percent (wet volume basis), and the carbon monoxide concentration ranges from 0 to 500 ppmv (wet volume basis).

Operating data recorded by plant personnel in the daily operating log include black liquor flow rate, solids content, density, and temperature as well as combustion air and exhaust gas flow rates and temperatures. The daily boiler operating logs were obtained for each test day and are presented in Appendix B.

3.3 ELECTROSTATIC PRECIPITATOR DESCRIPTION

Exhaust gases from black liquor recovery boiler BLB-C are cooled as they pass through the laminar air heaters and are then split into two streams of

TABLE 3-2. CHLORIDE CONCENTRATIONS IN LIQUOR CIRCUIT AT SITE BLB-C

Stream	Chloride Concentration ppm, wet basis				Average mass flow rate (lb/hr)
	Run 01	Run 02	Run 03	Average	
Vanillin Black Liquor	541.5	1052.7	NA	800	12.0
Microsul	NA	NA	511.6	512	0.3
Make-up water	1	3	4	3	2.3

NA = not added to liquor circuit during test run.

approximately equal flow rate. The cooled gases are sent to a Wheelabrator 2-section, dry-bottom electrostatic precipitator. The operating temperature of the precipitator is typically about 155°C (310°F) and ranges from approximately 120 to 175°C (250°-350°F).

Particulate matter captured by the precipitator is screw conveyed (dry) back to the black liquor circuit. Exhaust gases from the precipitator are vented through a stack with a release height of 77 m (253 ft) relative to grade level and an exit diameter of 3.4 m (11 ft). The grade level at the base of the stack is 6.7 m (22 ft) above sea level.

A schematic diagram of the electrical field layout of the precipitator is shown in Figure 3-2. Electrical operating data recorded in the daily precipitator log include voltage and current measurements for the inlet, middle, and outlet fields of the east and west sections of the precipitator. Inlet gas temperature data for the precipitator are recorded on the daily boiler log. The daily precipitator operating logs were obtained for each test day, and are presented in Appendix B.

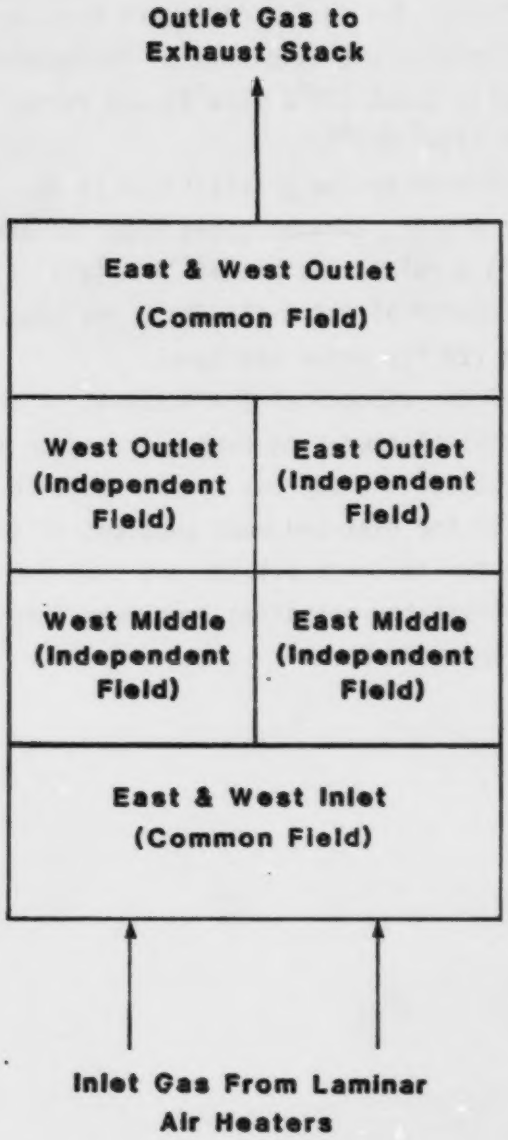
Outlet Gas to Exhaust Stack
East & West Outlet (Common Field)
West Outlet (Independent Field)
East Outlet (Independent Field)
West Middle (Independent Field)
East Middle (Independent Field)
East & West Inlet (Common Field)
Inlet Gas From Laminar Air Heaters

Figure 3-2. Schematic Electric Field Diagram of the Electrostatic Precipitator In Black Liquor Recovery Boiler System BLB-C

4.0 TEST DESCRIPTION

This section describes the field sampling, process monitoring, and analytical activities that were performed at Site BLB-C. The purpose of this section is to provide sufficient descriptive information about the test so that the test data presented in Section 5.0 can be easily understood. Specific testing details (specific sampling locations and procedures) will be presented later, in Section 6.0.

This section is divided into three parts. Section 4.1 summarizes field sampling activities, Section 4.2 summarizes process monitoring activities, and Section 4.3 summarizes analytical activities performed during the test program.

4.1 FIELD SAMPLING

Table 4-1 shows the source sampling and analysis matrix for Site BLB-C. Three dioxin/furan emissions tests (Runs 01, 02, 03) were performed, with simultaneous testing at the electrostatic precipitator outlet exhaust stack and the electrostatic precipitator inlet location. These locations are shown as Points A and B on Figure 4-1. Dioxin/furan sampling followed the Modified Method 5 (MM5) sampling protocol developed by the American Society of Mechanical Engineers (ASME) for measuring emissions of chlorinated organic compounds. Several modifications which are discussed in Chapter 6, were made in the ASME protocol. Testing was performed at the electrostatic precipitator outlet stack for a period corresponding to 240 minutes of on-line sampling. Testing was performed during the same time period at the electrostatic precipitator inlet location, but due to a number of filter changes and sample port changes the on-line sampling period for the inlet train was typically about 200 minutes.

Concentrations of HCl in the flue gas were determined during each MM5 test run at the electrostatic precipitator outlet stack using another modification of EPA Method 5. The sampling train was identical to that of Method 5 except that water in the impingers was replaced with 0.1 M KOH.

TABLE 4-1. SOURCE SAMPLING AND ANALYSIS MATRIX FOR SITE 08

Sample Location	Sample Type or Parameter	Sampling Method	Analytical Method	Number of Samples or Frequency
Gaseous Sampling				
1. Electrostatic precipitator outlet exhaust stack (Location A, Figure 4-1)	Dioxin, furan	Modified EPA Method 5 (MM5)	Gas chromatograph/mass spectrometer	Three test runs; one per test day
	Volumetric flow	EPA Method 2	S-type pitot	Once per MM5 test run
	Molecular weight	EPA Method 3	Gas chromatography/thermal conductivity detector	Two integrated bag samples per MM5 test run
	Moisture	EPA Method 4	Gravimetric balance	Once per MM5 test run
	HCl	Modified EPA Method 5 (MM5/HCl)	Ion chromatography	Once per MM5 test run
	CO/CO_2	In-stack filter probe and heat-traced Teflon sample line	Nondispersive infrared analyzer	Continuously during MM5 test runs
	O_2	Same as CO/CO_2	Paramagnetic analyzer	Continuously during MM5 test runs
	NO_x	Same as CO/CO_2	Chemiluminescent analyzer	Continuously during MM5 test runs
	SO_2	Same as CO/CO_2	Pulsed fluorescence analyzer	Continuously during MM5 test runs
	Total hydrocarbons (THC)	Same as CO/CO_2	Flame ionization analyzer	Continuously during MM5 test runs
2. Electrostatic precipitator inlet South Duct (Location B, Figure 4-1)	Dioxin, furan	Modified EPA Method 5	Gas chromatograph/mass spectrometer	Three test runs; one per test day
	Volumetric flow	EPA Method 2	S-type pitot	One per MM5 test run
	Molecular weight	EPA Method 3	Gas chromatography/thermal conductivity detector	Two integrated bag samples per MM5 test run
	Moisture	EPA Method 4	Gravimetric balance	Once per MM5 test run
3. Laminar air heater area (Location M, Figure 4-1)	Dioxin/furan Dioxin precursors	Ambient XAD train	Gas chromatograph/mass spectrometer	Two identical integrated samples during entire test program.

TABLE 4-1. SOURCE SAMPLING AND ANALYSIS MATRIX FOR SITE 08 (Continued)

Sample Location	Sample Type or Parameter	Sampling Method	Analytical Method	Number of Samples or Frequency
Liquid Sampling				
4. Strong black liquor feed guns	Strong black liquor for dioxin/furan, dioxin/furan precursors, and total chloride analyses	Dipper samples	Gas chromatography/mass spectrometer, ion chromatography	Three identical composites per MM5 test run of hourly samples taken during each run.
5. Fuel oil transfer line	Fuel oil for dioxin/furan, dioxin/furan precursors, and total chloride analyses	Tap valve samples	Gas chromatography/mass spectrometer, ion chromatography	Three identical composites of two samples taken during Run 3 only
6. White liquor storage tank	White liquor for total chloride analysis	Dipper samples	Ion chromatography	One composite per MM5 test run of two samples taken during the run.
7. Weak black liquor transfer line	Weak black liquor for total chloride analysis	Tap valve samples	Ion chromatography	One composite per MM5 test run of two samples taken during the run.
8. Vanillin black liquor transfer line	Vanillin black liquor for total chloride analysis	Tap valve samples	Ion chromatography	One composite per MM5 test run of two samples taken during the run. (Runs 1 and 2 only)
9. Microsul transfer line	Microsul for total chloride analysis	Tap valve samples	Ion chromatography	One composite per MM5 test run of two samples taken during Run 3 only
10. Pulp washer line shower	Make-up water for total chloride analysis	Grab samples	Ion chromatography	One composite per MM5 test run of two samples taken during the run.
11. Caustic line from storage	20% caustic for analysis	Dipper samples	Ion chromatography	One sample for the entire test program
Solid Sampling				
12. Electrostatic precipitator screw conveyor	Dioxin/furan	Grab samples	Gas chromatography/mass spectrometer	One composite per MM5 test run of two samples taken during the run.
13. Make-up lime screw conveyor	Make-up lime for total chloride analysis	Grab samples	Ion chromatography	One composite per MM5 test run of two samples taken during the run.
14. Plant property	Soils for dioxin, furan	Grab samples	Gas chromatograph/mass spectrometer	One composite of ten samples taken at various locations

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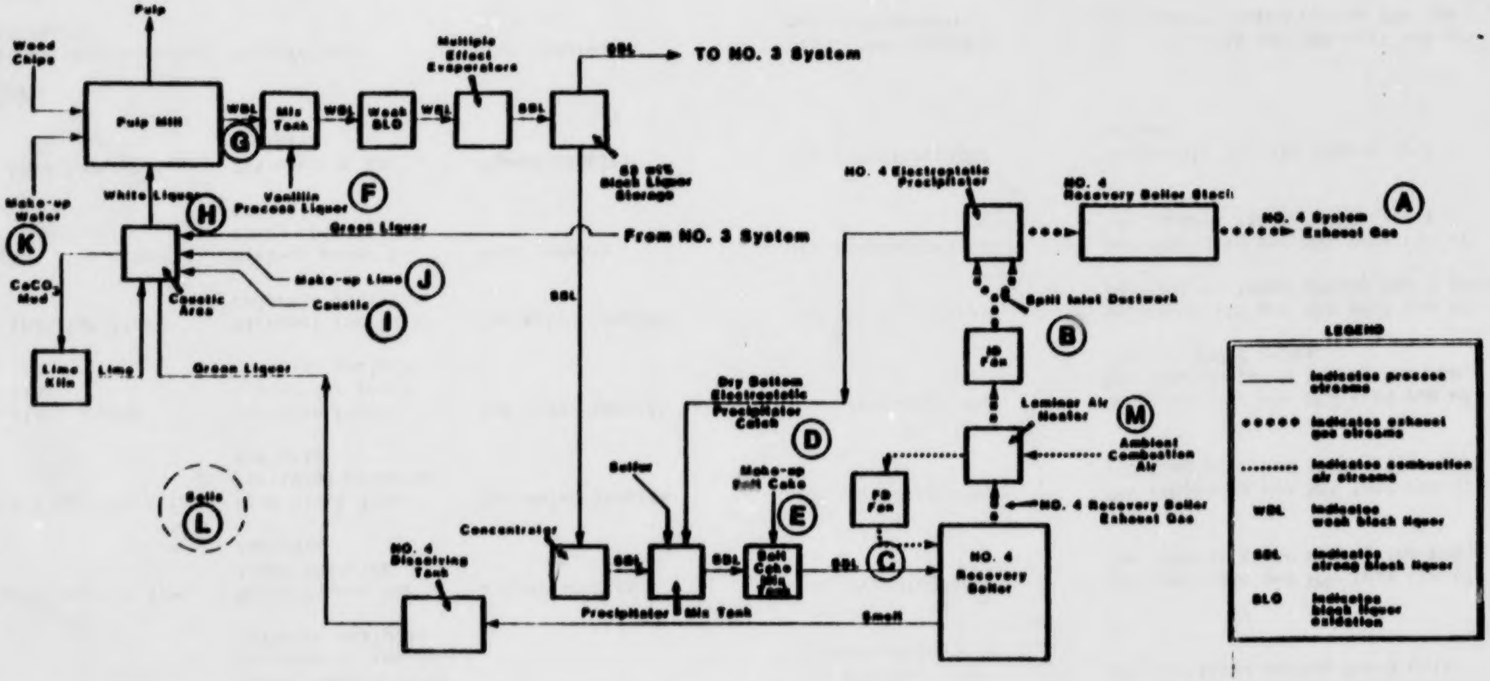

Pulp
Wood Chips
Pulp Mill
Make-up Water
K
WBL
G
Mix Tank
WBL
Weak BLO
WBL
Multiple Effect Evaporators
SBL
SBL
TO NO. 3 System
62 wt% Black Liquor Storage
Vanillin Process Liquor
F
White Liquor
H
Green Liquor
From NO. 3 System
CaCO3 Mud
Caustic Area
Make-up Lime
J
Caustic
I
Lime Kiln
Lime
Green Liquor
SBL
Salls
L
NO. 4 Dissolving Tank
Concentrator
SBL
Sulfur
Precipitator Mix Tank
SBL
Make-up Salt Cake
E
Salt Cake Mix Tank
SBL
C
Smelt
Dry Bottom Electrostatic Precipitator Catch
D
NO. 4 Electrostatic Precipitator
NO. 4 Recovery Boiler Stack
NO. 4 System Exhaust Gas
A
Split Inlet Ductwork
B
ID Fan
Laminar Air Heater
M
Ambient Combustion Air
FD Fan
NO. 4 Recovery Boiler Exhaust Gas
NO. 4 Recovery Boiler
LEGEND
Indicates process streams
Indicates exhaust gas streams
Indicates combustion air streams
WBL Indicates weak black liquor
SBL Indicates strong black liquor
BLO Indicates black liquor oxidation

Figure 4-1. Sample Point Diagram for Site 08, BLB-C

Continuous emissions monitoring (CEM) of O_2, CO, CO_2, SO_2, NO_x, and total hydrocarbons (THC) was performed at the electrostatic precipitator outlet stack during the three MM5 test runs. These data were obtained to assess variations in combustion during the sampling periods. Integrated average concentration values for each species monitored were determined every five minutes by the CEM system.

Ambient air sampling near the fresh air intake for the laminar air heaters was performed during the MM5 test runs using an ambient XAD train. Two identical trains were operated in parallel during the three MM5 runs, such that two identical integrated samples were obtained for the entire test program. One of the sample trains was analyzed for dioxin/furans. The other train was originally to be analyzed for dioxin precursors, but was not analyzed.

Two samples of electrostatic precipitator catch were obtained during each MM5 test run, and a single composite sample was developed for each run. The composite samples were analyzed for dioxin/furans. These samples were taken to develop data for the Tier 4 ash sampling program.

Hourly samples of strong black liquor were taken during each test run, and 3 identical composite samples were developed for each run. The strong black liquor composites for each run were submitted for dioxin/furan analysis. for dioxin precursor analysis and for total chloride analysis. Fuel oil samples were taken twice during Run 03, and three identical composites were prepared. The fuel oil composites were submitted for dioxin/furan analysis, for dioxin precursor analysis, and total chloride analysis. Several additional process samples were taken during the test runs to provide information on chlorine inputs to the black liquor circuit. These included white liquor, weak black liquor, vanillin black liquor, microsul, make-up water, and make-up lime. Samples of these materials were taken twice per MM5 test run, and one sample composite of each material was prepared for each test run. The composite samples were submitted for total chloride analysis.

Soil samples were collected from ten locations at the plant site. The ten samples were combined into a single composite, which was held for potential dioxin/furan analysis pending evaluation of the MM5 dioxin/furan emissions data.

4.2 PROCESS DATA COLLECTION

Process data were collected to characterize the operation of the black liquor boiler and the electrostatic precipitator during the MM5 test periods. Computer graphics displays available in the control room were printed and obtained for black liquor solids content; boiler steam flow and pressure; boiler exhaust gas oxygen, carbon monoxide and combustibles concentrations; black liquor feed rate; and combustion air flow rates. In addition, daily operating log reports were obtained for the boiler and the electrostatic precipitator. These process data will be used in Section 5.1 with the CEM data to evaluate and compare combustion conditions during the three MM5 test periods.

4.3 LABORATORY ANALYSES

Laboratory analyses performed on samples from test Site BLB-C included dioxin/furan analyses, dioxin/furan precursor analyses and total chloride analyses. Samples analyzed for dioxin/furan are discussed in Section 4.3.1 and samples analyzed for dioxin precursors are discussed in Section 4.3.2. Samples analyzed for chloride (Cl^-) are discussed in Section 4.3.3.

4.3.1 Dioxin/Furan Analyses

All dioxin/furan analyses for Site BLB-C samples were performed by EMSL-RTP and ECL-BSL laboratories, two of the three EPA laboratories collectively known as Troika. Dioxin/furan analyses were performed by gas chromatography/mass spectroscopy. Specific isomers identified included 2378 TCDD and 2378 TCDF. Other dioxin/furan compounds were quantified in groups according to the number of chlorine atoms per molecule. The tetra-through octa-chlorinated homologues were quantified.

4.3.2 Dioxin/Furan Precursor Analysis

Dioxin/furan precursor analyses of strong black liquor samples were performed by Radian using gas chromatograph/mass spectroscopy. The specific dioxin/furan precursors to be analyzed for included chlorophenols, chlorobenzenes, and PCB's. Composite feed samples were also analyzed for total chlorine by Parr Bomb Combustion followed by ion chromatography and for total organic halide by gas chromatography and Hall detector.

4.3.3 Total Chloride Analysis

Chloride analysis was performed on the combined probe-rinse/filter sample and on the back half-rinse/impinger solution sample for each HCl train (i.e., front half and back half analysis). Chloride analysis only was also performed on the strong black liquor, microsul, vanillin black liquor, and the make-up water.

5.0 TEST RESULTS

The results of the Tier 4 dioxin/furan emission test of Boiler BLB-C are presented in this section. The individual test runs are designated as Runs 01-03.

Process data obtained during the test runs are presented in Section 5.1, and continuous monitoring results for O_2, CO, CO_2, NO_x, SO_2, and THC are presented in Section 5.2. The dioxin/furan emissions data are contained in Section 5.3. Results of HCl train sampling at the precipitator outlet and chlorine analysis of various process samples are presented in Section 5.4. Dioxin/furan analysis and dioxin/furan precursor analysis data for the strong black liquor samples and dioxin/furan analysis data for the electrostatic precipitator catch samples are presented in Section 5.5.

5.1 PROCESS DATA

Process data were obtained to document black liquor boiler and electrostatic precipitator operation during the test runs. The boiler operating data are summarized in Section 5.1.1, and the electrostatic precipitator operating data are summarized in Section 5.1.2. In general, the data show that process operations were stable during the three test runs. Runs 01 and 02 were very similar in most respects, while Run 03 showed some differences in black liquor feed rate, auxiliary fuel firing rate, liquor circuit input materials, and electrostatic precipitator operation relative to Runs 01 and 02.

5.1.1 Black Liquor Boiler Operating Data

Mean values of plant-maintained operating data for black liquor boiler BLB-C during the three MM5 test runs are shown in Table 5-1. The data show that the overall boiler steam load was fairly constant between runs and averaged about 140 x 10^3 kg/hr (305 x 10^3 lb/hr) of steam at 2900 kPa (4300 psig). The maximum between-run variation in boiler load was about 4 percent. Black liquor feed rates were nearly equivalent for Runs 01 and 02 (0.83 cu meter/min, or 220 gpm), but were about 11 percent lower for Run 03

TABLE 5-1. MEAN OPERATING PARAMETERS FOR BLACK LIQUOR RECOVERY BOILER BLB-C

Parameter[a]	Run 01	Run 02	Run 03	Mean Runs 01-03
Black Liquor Flow (gpm)	221	212	197	212
Black Liquor Solids (%)	63.2	62.1	64.1	63.1
Fuel Oil Flow (gpm)	0	0	1.8	--
Boiler Steam Pressure (psig)	437	423	420	427
Steam Flow (10^3 lb/hr)	313	301	300	305
% Oxygen[b]	3.4	2.6	2.1	2.7
% Combustibles[b]	0	0.1	0.1	0.1

[a] **Data shown in units used by host plant:**

To convert from:	to:	multiply by:
gpm	cu meter/min	0.00379
psig	kPa	6.893
lb/hr	kg/hr	0.454

[b] Oxygen and combustibles monitoring performed by host plant at boiler outlet (prior to air dilution by laminar air heaters)

(0.75 cu meter/min, or 197 gpm). Approximately 0.008 cu meter/min (2 gpm) of Bunker C fuel oil was fired during Run 03 in order to maintain the boiler load at a constant value. The fuel oil is estimated to have provided roughly 10 percent of the total energy input to the boiler during Run 03. No fuel oil was fired during Runs 01 and 02.

The test program average black liquor feed rate of 0.8 cu meter/min (212 gpm) was approximately 20 percent below normal for boiler BLB-C, which more typically operates at a black liquor feed rate of 1.0 cu meter/min (270 gpm). A continuous digestor at the host plant went down for repair before Run 01 began, which led to a reduction in the amount of black liquor available for combustion during the test program. Although the digestor was repaired during Run 03, the load on Boiler BLB-C was maintained at a constant value until the testing was complete. The black liquor feed rate to the boiler was increased back to about 1.0 cu meter/min (270 gpm) shortly after Run 03 was complete.

The oxygen content of the boiler exhaust gas ranged from 2.1% O_2 (wet) to 3.4% O_2 (wet), as measured by the plant's monitors located upstream of the laminar air heaters. A significant amount of ambient air leakage occurs across the laminar air heaters. Total combustibles concentrations measured by the plant upstream of the laminar air heaters were near the lower sensitivity limit of the monitoring instrument, with the mean value for each test run being 0.1 percent or less.

Plant-maintained continuous monitoring data for boiler load (i.e., steam flow) and boiler exhaust gas concentrations of oxygen, carbon monoxide, and combustibles are shown in Figure 5-1 for each run. These plots are tracings of figures generated by a computer in the boiler control room. The data show that the boiler operation was stable during the test runs, with each run showing a comparable degree of variability.

Other parameters continuously monitored in the boiler control room at the host plant included black liquor feed rate and black liquor solids content. These parameters showed very little within-run variability. The mean black liquor solids content for the three test runs was 63.1 weight percent.

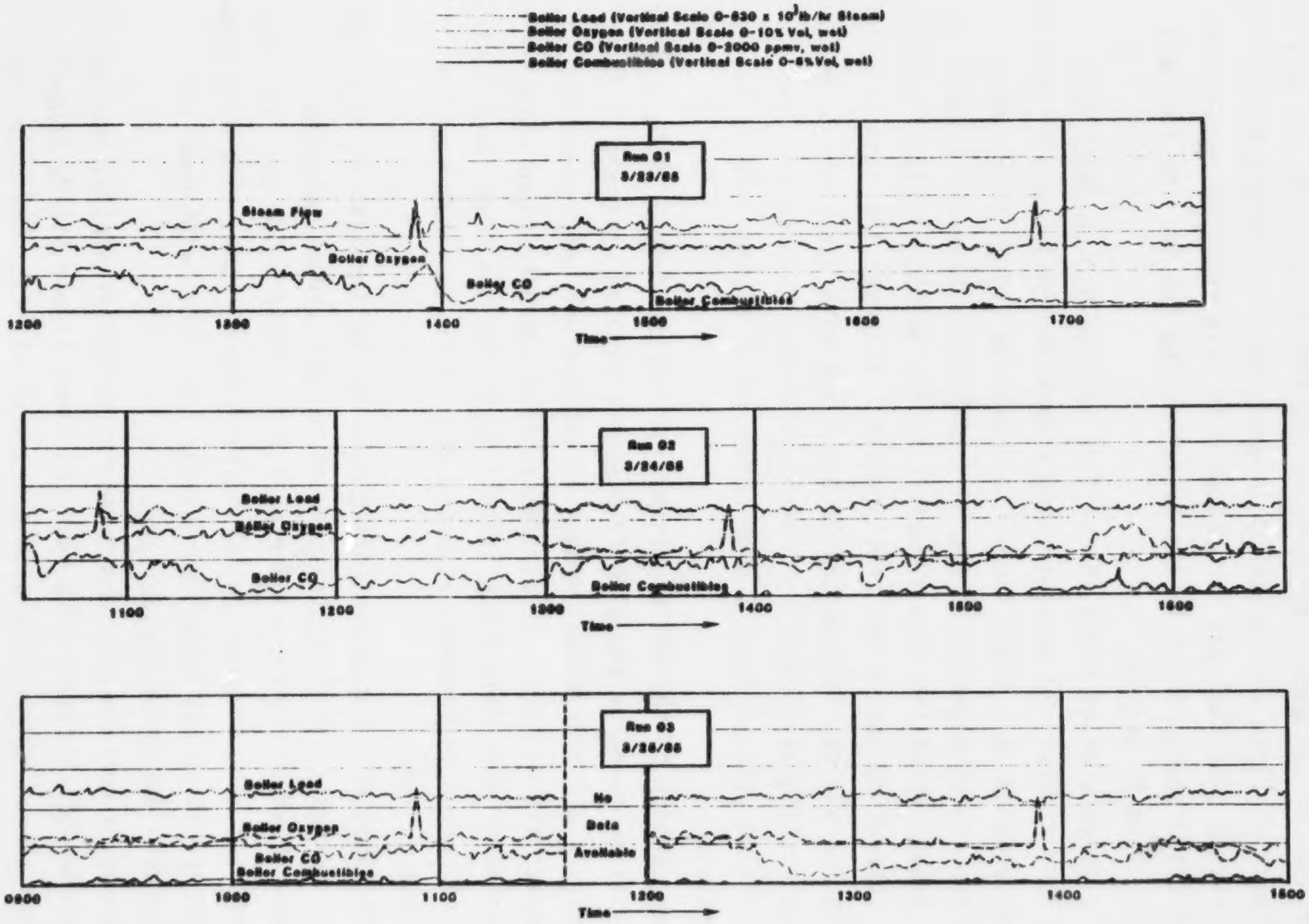


Figure 5-1. Continuous Steam Load and Exhaust Gas Composition Data for Black Liquor Recovery Boiler BLB-C (Plant Data)

The liquor circuit input materials changed between Run 2 and Run 3. The vanillin black liquor used during Runs 01 and 02 was replaced with the microsul used during Run 03. The vanillin black liquor and microsul serve as sources of make-up sodium and sulfur for the black liquor circuit. The replacement of vanillin black liquor with microsul was performed by plant personnel in order to maintain the desired sodium to sulfur ratio in the liquor circuit.

5.1.2 Electrostatic Precipitator Operating Data

Mean operating data for the electrostatic precipitator are shown for each test run in Table 5-2. The data show that the measured gas flow rates and temperatures were fairly consistent between runs. The mean total inlet gas flow rate to the precipitator was 4700 Nm^3/min (166,000 dscfm), with a maximum deviation from the mean being less than 7 percent for any run. The total inlet gas flow rate was calculated as the sum of the flow rates measured in the two halves of the split inlet ductwork. The gas flow rates measured in the west half of the inlet ductwork were an average of 20 percent higher than those measured in the east half of the inlet ductwork. As discussed in Section 6.1.1.2, the inlet sampling locations did not meet the requirements specified in EPA Method 1 for velocity determination and the port locations on the two ductwork halves were not identical. Thus, it is difficult to determine whether the measured flow data reflects a real difference in flow rates for the two ductwork halves or whether the measured difference is attributable to sampling uncertainty. The total outlet gas flow rates measured at the exhaust stack location agreed with the total inlet gas flow rates. The average deviation between the two values was approximately 4 percent. This indicates very little gas inleakage across the precipitator. The mean gas inlet temperature to the precipitator was 156°C (312°F), with a maximum deviation for any run of less than 3 percent from the mean. Temperatures measured in the west inlet duct were typically about 3°C (5°F) higher than those measured in the east inlet duct.

TABLE 5-2. MEAN GAS TEMPERATURE AND FLOW RATE DATA FOR THE ELECTROSTATIC PRECIPITATOR SERVING BLACK LIQUOR RECOVERY BOILER BLB-C

Parameter[a,b]	Run 01	Run 02	Run 03	Average
Gas Temperatures (°F)				
East Inlet	315	302	310	309
West Inlet	318	307	315	313
Avg. Inlet	317	305	313	312
Outlet Stack	292	294	297	294
Gas Flow Rates (dscfm)				
East Inlet	76,500	76,600	71,600	74,900
West Inlet	97,700	92,700	84,000	91,500
Total Inlet	174,200	169,300	155,600	166,400
Outlet Stack	175,300	174,300	169,100	172,900

[a] Inlet gas temperature data obtained from host plant measurements. Outlet stack temperatures measured by Radian. To convert from °F to °C, use the formula °C = (°F - 32)/1.8

[b] Gas flow rate measured by Radian. To convert from dscfm to dscmm, multiply value in dscfm by 0.0283

Electrical power consumption data and the operating status of the electrical fields of the precipitator are shown for each run in Table 5-3. The electrostatic precipitator power consumption data show that the average power consumption of the precipitator was about 240 kw (0.8 MM Btu/hr) during Runs 01 and 02. When the final electrical field was brought on-line prior to Run 03, the power consumption increased about 20 percent to 290 kw (1.0 MM Btu/hr). These values were calculated from load voltage and load current data monitored by the host plant for each electrical field of the precipitator. The voltage and current data obtained during the test periods are summarized in Appendix B.

The final electrical field common to the east and west halves of the precipitator (i.e., "E & W Outlet") was not operating during Runs 01 and 02. A diode in the transformer for that field malfunctioned the week before the testing was performed. The diode was repaired during the week that testing was performed, and the electrical field was brought back on-line after the completion of Run 02. The decision to proceed with testing prior to the repair of the electrical field was based primarily on EPA Method 5 testing performed by the host plant on April 18, after the malfunction occurred. The Method 5 data indicated that particulate emissions from the precipitator were on the order of 0.024 gr/dscf (0.03 gr/dscf corrected to 8% O_2), which was about a factor of 3 lower than the level allowed by the applicable local permit (0.10 gr/dscf corrected to 8% O_2). The opacity of the stack gases from the precipitator was approximately 12 percent with the final field out of service. This was within the permitted value of 35 percent opacity for recovery boilers. Plant personnel indicated there was no significant increase in either the particulate emissions or the outlet opacity with the final common electrical field out of service, relative to levels measured previously with all fields of the precipitator operating.

5.2 FLUE GAS PARAMETER DATA

Table 5-4 summarizes flue gas temperature, moisture, volumetric flowrate and oxygen concentration data obtained at Site BLB-C. These parameters were

TABLE 5-3. POWER CONSUMPTION DATA AND ELECTRICAL FIELD OPERATING STATUS FOR THE ELECTROSTATIC PRECIPITATOR SERVING BLACK LIQUOR RECOVERY BOILER BLB-C

Parameter	Run 01	Run 02	Run 03	Average
Total Electrical Power Consumption[a] (kw)	239	245	290	258
Operating Status of Electrical Fields				
E & W Inlet	Operating	Operating	Operating	Always Operating
E Middle	Operating	Operating	Operating	Always Operating
E Outlet	Operating	Operating	Operating	Always Operating
W Outlet	Operating	Operating	Operating	Always Operating
E & W Outlet	Not Operating	Not Operating	Operating	Operating Run 03 only

[a] Total electrical power consumption data calculated from load voltage and load load current data maintained by the host plant for each electrical field. To convert from kw to MMBtu/hr, multiply value in kw by 0.003413.

TABLE 5-4. FLUE GAS PARAMETERS AT SITE BLB-C

Parameter	Run 01	Run 02	Run 03	Average
Inlet to ESP:[a]				
Temperature (^{o}C)	158	154	152	155
Moisture (vol%)	18.1	20.0	19.8	19.3
Volumetric Flow Rate:				
actual (acmm)	8800	8600	7900	8400
dry standard (dscmm)[b]	4900	4800	4400	4700
Oxygen Content (vol%):				
EPA Method 3	12.7	13.3	12.1	12.7
Outlet Stack:				
Temperature (^{o}C)	144	146	147	146
Moisture (vol%)	19.1	19.8	19.7	19.5
Volumetric Flowrate:				
actual (acmm)	8700	8700	8500	8600
dry standard (dscmm)	5000	4900	4800	4900
Oxygen Content (vol%):				
Radian CEM	12.3	12.1	12.2	12.2
EPA Method 3	13.8	14.0	13.6	13.8

---

[a] Method 5 sampling was conducted in the east inlet duct to the ESP, and Method 2 was conducted in the west inlet duct, these values are based on the results from both sides as follows:
- temperature: average
- moisture: east duct
- oxygen content: east duct
- volumetric flowrate: sum of east and west duct

[b] EPA standard conditions: 20^{o}C (68^{o}F) and 1 atm

consistent for all three test runs. At the inlet to the ESP, the average gas temperature was 155°C, the average moisture content of the stack gas was 19.3 vol%, the average volumetric flowrate was 8400 acmm and the average oxygen content as measured by EPA Method 3 was 12.7 vol %. At the ESP outlet, the average gas temperature was 146°C, the average moisture was 19.5 vol%, the average volumetric flowrate was 8600 acmm and the average oxygen content was 13.0 vol%. Radian CEM and EPA Method 3 oxygen data agreed within the measurement error of the methods. The flue gas parameters at the inlet and outlet to the ESP are in fair agreement, which indicates that little air inleakage occurred across the ESP.

5.3 CONTINUOUS EMISSIONS MONITORING DATA

Mean values and standard deviations of the continuously monitored combustion gases at the electrostatic precipitator outlet location (O_2, CO, O_2, SO_2, NO_x and THC) are shown for each MM5 test run in Table 5-5. The overall mean values for the three test runs are as follows: oxygen, 12.2 percent by volume (dry); carbon monoxide, 860 ppmv (dry @ 3% O_2); carbon dioxide, 17 percent by volume (dry @ 3% O_2); sulfur dioxide, 80 ppmv (dry @ 3% O_2); nitrogen oxides, 41 ppmv (dry @ 3% O_2); and total hydrocarbons, 23 ppmv (wet @ 3% O_2, as propane).

The mean oxygen, carbon dioxide, sulfur dioxide, and nitrogen oxides concentrations showed little between-run variability. The maximum deviation between the mean concentration for any run and the overall mean value for all runs was less than 20 percent for these species. The mean carbon monoxide and total hydrocarbon concentrations showed considerable variability between runs. The total hydrocarbon concentration for Run 01 (46 ppmv @ 3% O_2) was approximately four times higher than that for Runs 02 and 03 (approximately 11 ppmv @ 3% O_2), while the carbon monoxide concentration for Run 01 (570 ppmv @ 3% O_2) was nearly a factor of two lower than that for Runs 02 and 03 (1000 ppmv @ 3% O_2). This trend does not show the expected positive relationship between carbon monoxide and total hydrocarbon concentrations.

Five-minute average values of the continuously monitored combustion gases are tabulated in Appendix A-2 and are shown graphically as functions of time in Figures 5-2 through 5-7. The oxygen concentration showed regular, cyclical

TABLE 5-5. MEAN VALUES AND STANDARD DEVIATIONS OF CONTINUOUSLY MONITORED COMBUSTION GASES AT THE ELECTROSTATIC PRECIPITATOR OUTLET

Parameter[a,b,c]	Mean Value and Standard Deviation[d]			
	Run 01	Run 02	Run 03	Overall Mean
O_2 (% vol)	12.3 (1.1)	12.1 (1.2)	12.2 (1.1)	12.2
CO (ppmv @ 3% O_2)	586.6 (304.9)	997.7 (396.8)	1023.6 (371.0)	863
CO_2 (% vol @ 3% O_2)	17.1 (0.5)	16.6 (0.7)	17.2 (0.5)	17.0
SO_2 (ppmv @ 3% O_2)	ND[e]	64.9 (30.1)	95.6 (51.1)	80.3
NO_x (ppmv @ 3% O_2)	40.0[f]	42.7 (3.9)	39.9 (3.7)	40.9
THC (ppmv @ 3% O_2)	46.3 (21.9)	10.6 (4.8)	12.2 (6.0)	23.0

[a] Gas sampling for the continuous monitors was performed at the electrostatic precipitator outlet location.

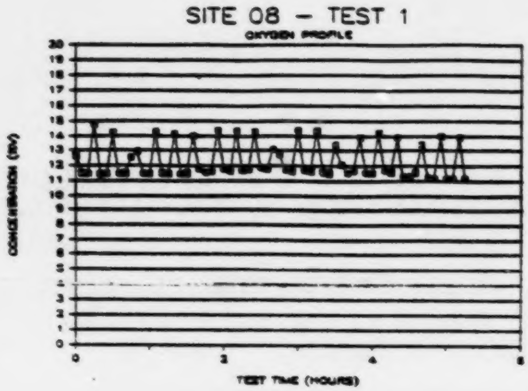
[b] All concentrations are expressed on a dry volume basis except for total hydrocarbon concentrations, which are expressed on a wet volume basis.

[c] Total hydrocarbon data are expressed in units of ppmv (wet) as propane.

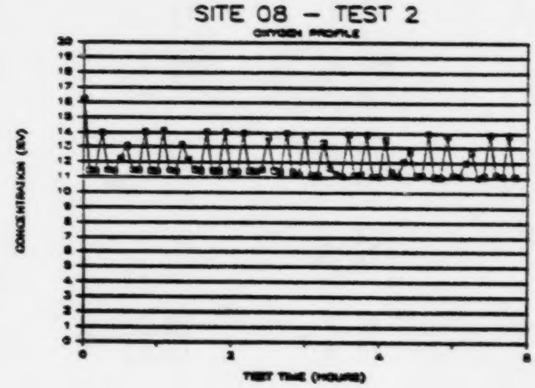
[d] Mean values shown on top, with standard deviation below in parenthesis.

[e] ND = no data available for the test run.

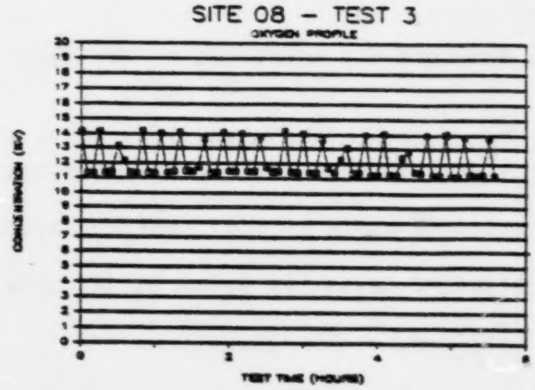
[f] Mean nitrogen oxides concentration for Run 01 includes only the data obtained after the instrument range was changed from 0 - 1000 ppmv to 0 - 250 ppmv.



MEAN: 12.3% O2
STD. DEV.: 1.1%
INSTRUMENT RANGE: 0-25% O2



MEAN: 12.1% O2
STD. DEV.: 1.2%
INSTRUMENT RANGE: 0-25% O2



MEAN: 12.2% O2
STD. DEV.: 1.1%
INSTRUMENT RANGE: 0-25% O2

Figure 5-2. Oxygen Concentration History at the Electrostatic Precipitator Outlet Location

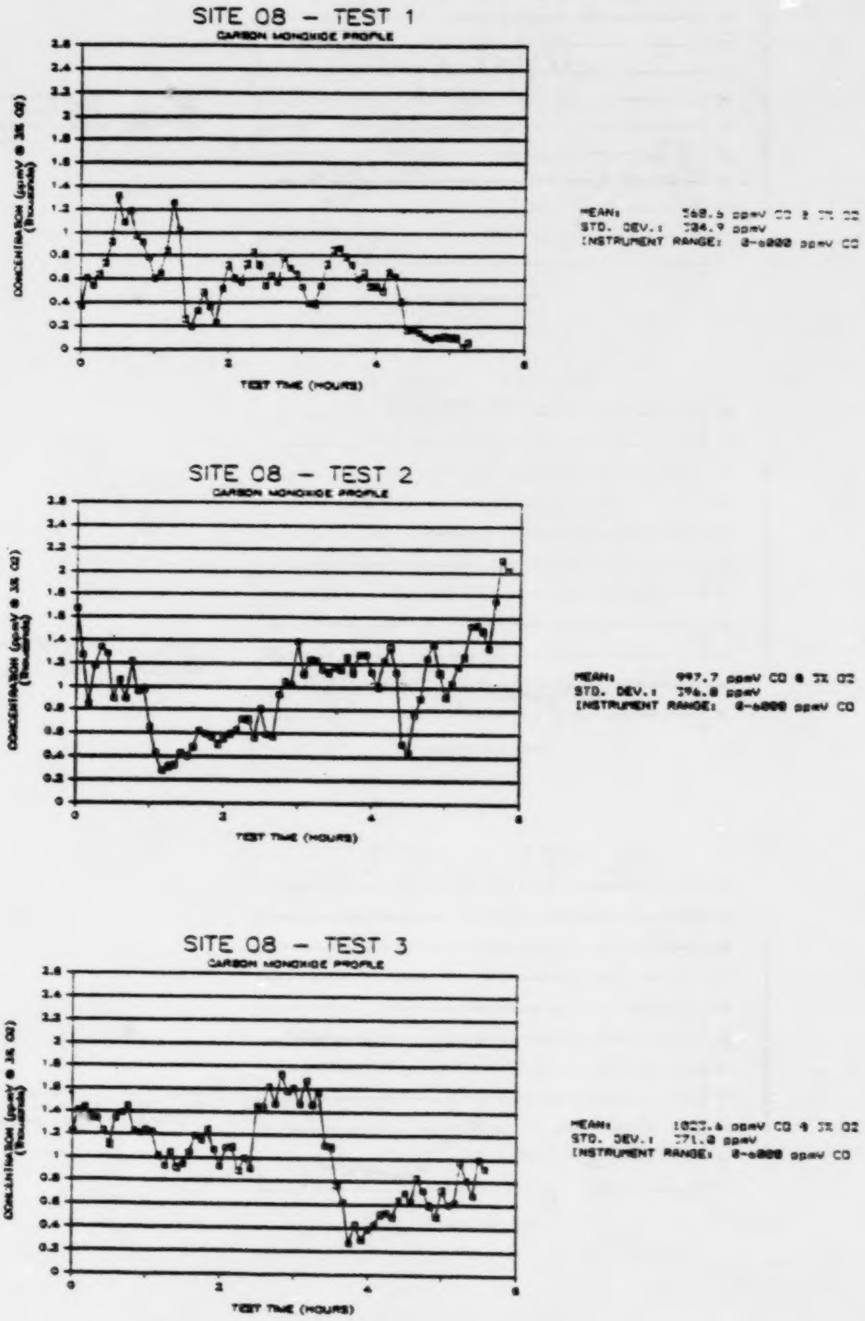
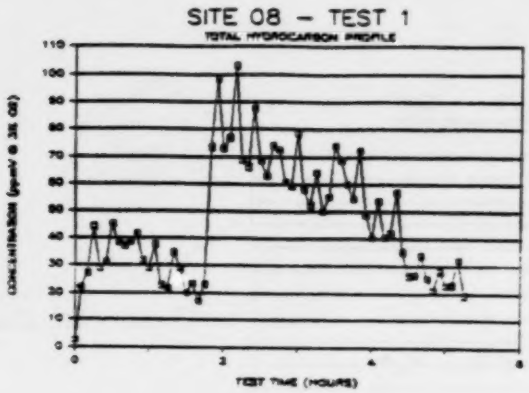
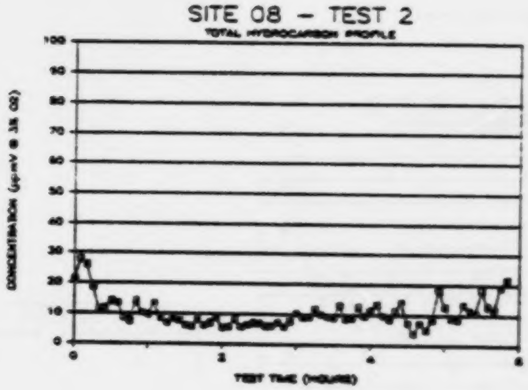


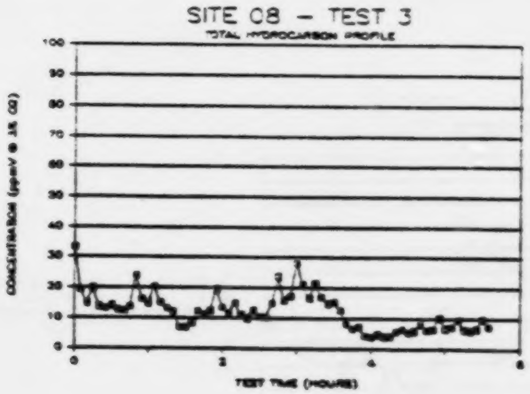
Figure 5-3. Carbon Monoxide Concentration History at the Electrostatic Precipitator Outlet Location



MEAN: 46.3 ppmV THC @ 3% O2
STD. DEV.: 21.9 ppmV
INSTRUMENT RANGE: 0-1000 ppmV THC for first :
1-100 ppmV THC for remainde

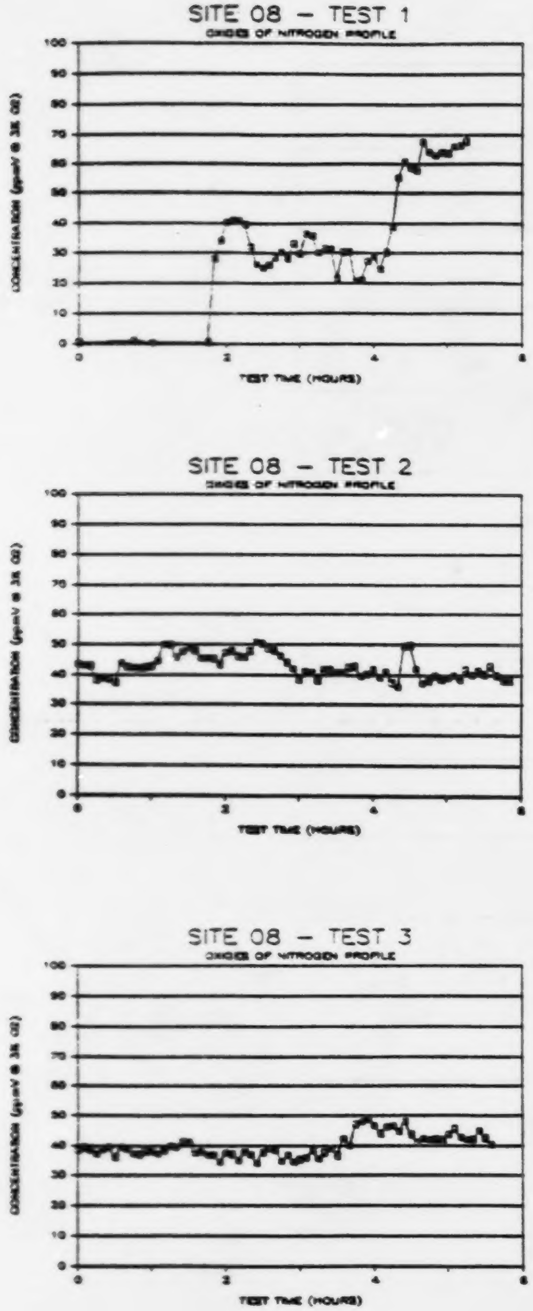


MEAN: 10.6 ppmV THC @ 3% O2
STD. DEV.: 4.8 ppmV
INSTRUMENT RANGE: 0-100 ppmV THC



MEAN: 12.2 ppmV THC @ 3% O2
STD. DEV.: 5.8 ppmV
INSTRUMENT RANGE: 0-100 ppmV THC

Figure 5-4. Total Hydrocarbon Concentration History at the Electrostatic Precipitator Outlet Location

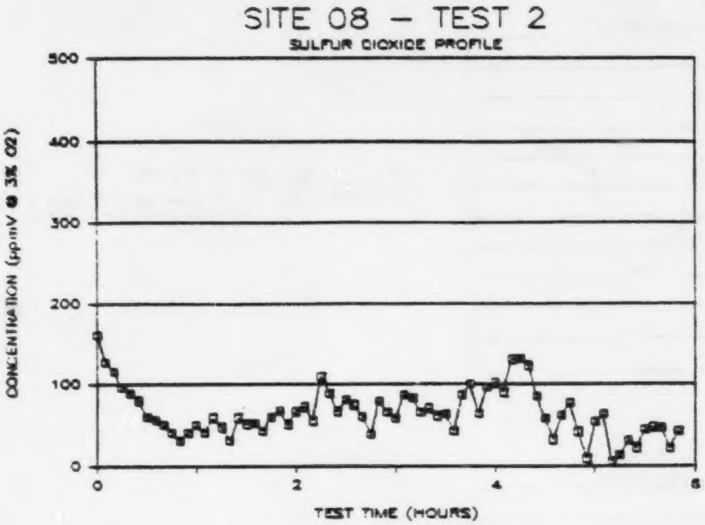


MEAN: 26.3 ppmV NOx @ 3% O2
STD. DEV.: 22.7 ppmV
INSTRUMENT RANGE: 0-1000 ppmV NOx for first 1
1-250 ppmV NOx for remainde

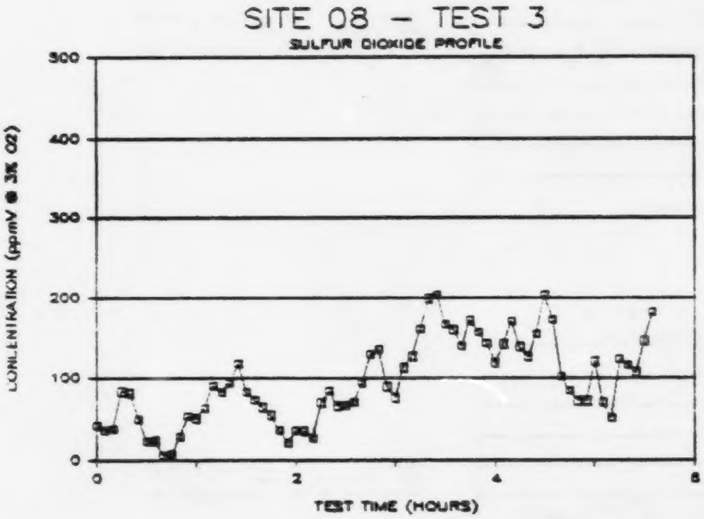
MEAN: 42.7 ppmV NOx @ 3% O2
STD. DEV.: 3.9 ppmV
INSTRUMENT RANGE: 0-250 ppmV NOx

MEAN: 39.9 ppmV NOx @ 3% O2
STD. DEV.: 3.7 ppmV
INSTRUMENT RANGE: 0-250 ppmV NOx

Figure 5-5. Nitrogen Oxides Concentration History at the Electrostatic Precipitator Outlet Location

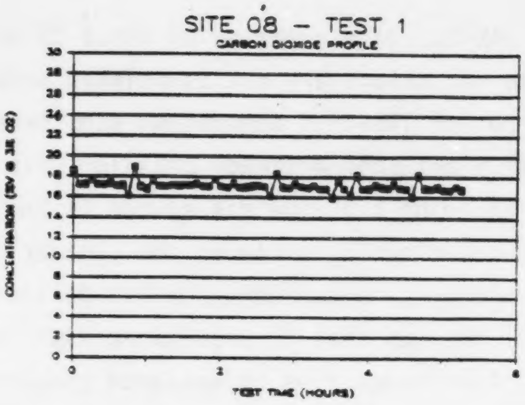


MEAN: 64.9 ppmV SO2 @ 3% O2
STD. DEV.: 30.2 ppmV
INSTRUMENT RANGE: 0-1200 ppmV SO2



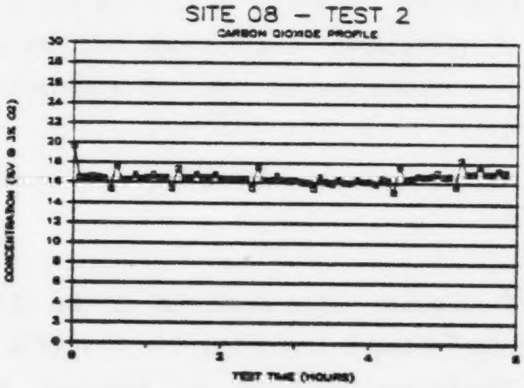
MEAN: 95.6 ppmV SO2 @ 3% O2
STD. DEV.: 51.1 ppmV
INSTRUMENT RANGE: 0-1000 ppmV SO2

Figure 5-6. Sulfur Oxides Concentration History at the Electrostatic Precipitator Outlet Location


SITE 08 – TEST 1

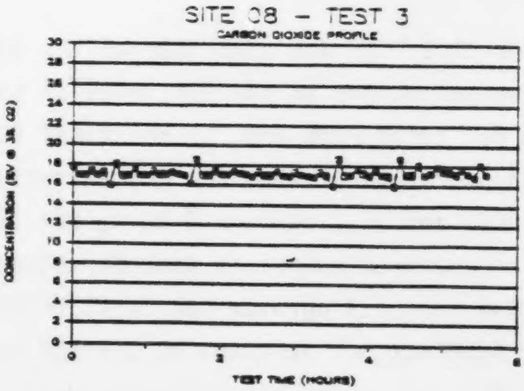
CARBON DIOXIDE PROFILE

MEAN: 17.1% V CO2 @ 3% O2
STD. DEV.: 0.5% V
INSTRUMENT RANGE: 0-20% V CO2


SITE 08 – TEST 2

CARBON DIOXIDE PROFILE

MEAN: 16.6% V CO2 @ 3% O2
STD. DEV.: 0.7% V
INSTRUMENT RANGE: 0-20% V CO2


SITE 08 – TEST 3

CARBON DIOXIDE PROFILE

MEAN: 17.2% V CO2 @ 3% O2
STD. DEV.: 0.5% V
INSTRUMENT RANGE: 0-20% V CO2

Figure 5-7. Carbon Dioxide Concentration History at the Electrostatic Precipitator Outlet Location

variation from about 11% O_2 to 14% O_2, with a period of about 15 minutes between the 14% O_2 peaks. These variations are not associated with combustion conditions in the black liquor boiler itself. Continuous monitoring performed at the boiler outlet by the host plant showed steady behavior with no cyclical trends. The extra "tramp" air entering the flue gas system is believed to be associated with a regular air pulse cleaning cycle on the laminar air heaters.

The total hydrocarbon and nitrogen oxides data for Run 01 show anomalous behavior during the beginning of the run that is associated with range changes on the monitoring instruments. The sudden rise in measured concentration for these parameters that occur after approximately 2 hours of run time does not reflect a change in combustion condition in the boiler. The first 2 hours of concentration data for both total hydrocarbon and nitrogen oxides are considered invalid because the instrument ranges were not appropriate for the concentrations being measured.

5.4 DIOXIN/FURAN EMISSIONS DATA

Emission concentrations and emission rates measured at the ESP inlet and outlet locations are summarized in Tables 5-6 and 5-7 for the 2378 TCDD, total PCDD, and total PCDF species. The entire MM5 train was analyzed, which included the filter, primary XAD sorbent trap, impingers, and sample train clean-up rinses was analyzed.

Values were not reported for 2378 TCDD and 2378 TCDF at the ESP inlet. Average as-measured emissions concentrations at the ESP inlet of total PCDD and total PCDF were 4.1 ng/dscm for total PCDD and 7.0 for total PCDF. Corrected to 3% O_2 using the Radian Method 3 data, the concentrations were 9.00 ng/dscm @ 3% O_2 for total PCDD and 15.1 ng/dscm @ 3% O_2 for total PCDF.

At the ESP outlet average as-measured emissions concentrations of the total PCDD, and total PCDF species were 2.3 ng/dscm for total PCDD; and 1.1 ng/dscm for total PCDF. 2,3,7,8 TCDD was not detected at the ESP outlet. Corrected to 3% O_2 using the Radian CEM oxygen concentration data, these values correspond to 2.94 ng/dscm PCDD @ 3% O_2; and 2.11 ng/dscm PCDF @ 3% O_2, respectively.

TABLE 5-6. OVERVIEW OF DIOXIN AND FURAN EMISSIONS CONCENTRATION DATA FOR SITE BLB-C

Run	Emissions Concentration, ng/dscm 2378 TCDD[a]	Total PCDD	Total PCDF
ng/dscm as-measured			
Inlet:			
Run 01	NR	5.76	17.7
Run 02	NR	3.28	1.8
Run 03	NR	3.38	1.38
Average	NR	4.14	6.97
Outlet:			
Run 01	ND (0.010)	0.53	0.38
Run 02	ND (0.005)	4.94	1.26
Run 03	ND (0.003)	1.33	1.76
Average	ND (0.006)	2.27	1.13
ng/dscm @ 3% O_2			
Inlet:			
Run 01	NR	12.5	38.4
Run 02	NR	7.66	4.21
Run 03	NR	6.83	2.80
Average	NR	9.00	15.1
Outlet:[b]			
Run 01	ND (0.02)	1.32	0.96
Run 02	ND (0.004)	4.27	1.08
Run 03	ND (0.006)	3.24	4.28
Average	ND (0.01)	2.94	2.11

[a] The value in parenthesis is the detection limit converted to ng/dscm

[b] Flue gas concentration data corrected to 3% O_2 using the average Radian CEM data in Table 5-5.

NR = not reported

ND = not detected

ng = 1×10^{-9}g

TABLE 5-7. SUMMARY OF DIOXIN AND FURAN EMISSION RATE DATA FOR SITE BLB-C

Run	Emission Rate (ug/hr)		
	2378 TCDD[a]	Total PCDD	Total PCDF
INLET:			
Run 01	NR	1500	4610
Run 02	NR	850	470
Run 03	NR	820	340
Average	NR	1060	1810
OUTLET:			
Run 01	ND (2.9)	160	115
Run 02	ND (1.3)	1500	370
Run 03	ND (0.7)	380	500
Average	ND (1.6)	680	330

[a] Values in parenthesis are detection limits expressed in corresponding units.

NR = not reported.

ND = not detected

Average emission rates at the ESP inlet were 1060 ug/hr for total PCDD and 1810 ng/hr for total PCDF. At the ESP outlet, average emission rates were 680 ug/hr for total PCDD and 330 ug/hr for total PCDF.

The PCDD and PCDF emission rates appear to be significantly different. However, for the ESP inlet data, the total PCDD and total PCDF emission rates for Run 1 are signficantly higher than Runs 1 and 3. If these values are removed from the averages, the inlet and outlet values for PCDDs are still significantly different, but the PCDF values are not significantly different.

5.4.1 Isomer and Homologue Specific Data at the ESP Inlet

Isomer and homologue specific emissions concentration data at the ESP Inlet are summarized in Tables 5-8 and 5-9 for the three test runs. Run-specific data tables showing homologue emissions concentrations in ng/dscm, parts-per-trillion and ug/hr units are included in Appendix D. All dioxin/furan isomers were detected at the inlet to the ESP. Penta-CDF and octa-CDF were not detected in the Run 3 sample and were close to the minimum detection in the Run 2 sample.

Analysis of the inlet and outlet samples did indicate that the 2378 TCDD/TCDF isomers were minor components (less than 25 percent) of the total TCDD/TCDF concentrations in most cases. Isomer-specific analyses were performed on all samples in those cases where the first analysis (not isomer-specific) indicated that the 2378-TCDD/TCDF isomers were present in higher than normal or expected concentrations. As a result, it will be noted that for some isomer-specific analyses the results were not reported (NR) by Troika. In these cases, it should be assumed that the 2378-TCDF/TCDF isomers are a minor component of the total TCDD/TCDF concentrations.

The relative distribution of the dioxin and furan isomers for the ESP inlet are shown graphically in Figure 5-8. For the dioxin homologues, hexa-CDD was the most prominent homologue at 30 mole %, while other TCDD, penta-CDD, hepta-CDD and octa-CDD were evenly distributed among the remaining 70 mole %. Other-TCDF dominated the furan homologues at 45 mole %. Penta-CDF and hexa-CDF were about the same at 25 mole % each, followed by hepta-CDF at 7 mole % and octa-CDF at 3 mole %.

Isomer and homologue-specific emission factors for the ESP inlet are summarized in Table 5-10. The emission factors are reported as micrograms of

TABLE 5-8. SUMMARY OF DIOXIN/FURAN EMISSIONS DATA AT THE ESP INLET FOR SITE BLB-C

Dioxin/Furan Isomer	Isomer Concentration in Flue Gas (ng/dscm) Run 01	Run 02	Run 03	Avg.
DIOXINS				
2378 TCDD	NR	NR	NR	NR
Other TCDD	8.10E-01	3.26E-01	3.86E-01	5.07E-01
Penta-CDD	1.03E+00	4.81E-01	4.50E-01	6.53E-01
Hexa-CDD	1.59E+00	1.02E+00	1.09E+00	1.24E+00
Hepta-CDD	1.40E+00	7.92E-01	7.72E-01	9.88E-01
Octa-CDD	9.35E-01	6.52E-01	6.75E-01	7.54E-01
Total PCDD	5.76E+00	3.28E+00	3.38E+00	4.14E+00
FURANS				
2378 TCDF	NR	NR	NR	NR
Other TCDF	6.17E+00	6.37E-01	7.07E-01	2.50E+00
Penta-CDF	5.89E+00	3.73E-01	ND(4.18E-01)	2.09E+00
Hexa-CDF	4.36E+00	5.12E-01	5.14E-01	1.80E+00
Hepta-CDF	1.15E+00	1.86E-01	1.61E-01	5.00E-01
Octa-CDF	1.56E-01	9.32E-02	ND(9.65E-02)	8.30E-02
Total PCDF	1.77E+01	1.80E+00	1.38E+00	6.97E+00

NOTE: Isomer concentrations shown are at as-measured oxygen conditions.

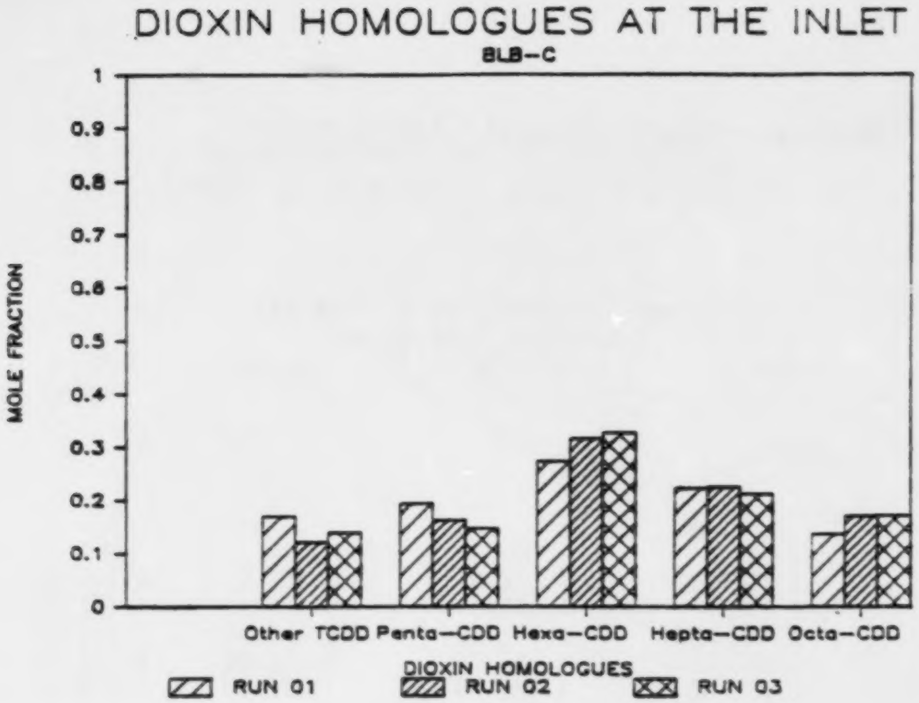
ND = not detected (detection limit in parentheses).
ng = 1.0E-09g
8760 operating hours per year
NR = not reported.

TABLE 5-9. SUMMARY OF DIOXIN/FURAN EMISSIONS
DATA AT THE ESP INLET FOR SITE BLB-C
(Concentrations Corrected to 3% Oxygen)

Dioxin/Furan Isomer	Isomer Concentration in Flue Gas (ng/dscm @ 3% oxygen)			
	Run 01	Run 02	Run 03	Avg.
DIOXINS				
2378 TCDD	NR	NR	NR	NR
Other TCDD	1.76E+00	7.62E-01	7.80E-01	1.10E+00
Penta-CDD	2.23E+00	1.13E+00	9.10E-01	1.42E+00
Hexa-CDD	3.45E+00	2.40E+00	2.21E+00	2.68E+00
Hepta-CDD	3.04E+00	1.85E+00	1.56E+00	2.15E+00
Octa-CDD	2.03E+00	1.52E+00	1.37E+00	1.64E+00
Total PCDD	1.25E+01	7.66E+00	6.83E+00	9.00E+00
FURANS				
2378 TCDF	NR	NR	NR	NR
Other TCDF	1.34E+01	1.49E+00	1.43E+00	5.43E+00
Penta-CDF	1.28E+01	8.71E-01	ND(8.45E-01)	4.55E+00
Hexa-CDF	9.46E+00	1.20E+00	1.04E+00	3.90E+00
Hepta-CDF	2.50E+00	4.36E-01	3.25E-01	1.09E+00
Octa-CDF	3.38E-01	2.18E-01	ND(1.95E-01)	1.85E-01
Total PCDF	3.84E+01	4.21E+00	2.80E+00	1.51E+01

NOTE: Isomer concentrations shown are corrected to 3% oxygen.

ND = not detected (detection limit in parentheses).
ng = 1.0E-09g
8760 operating hours per year
NR = not reported



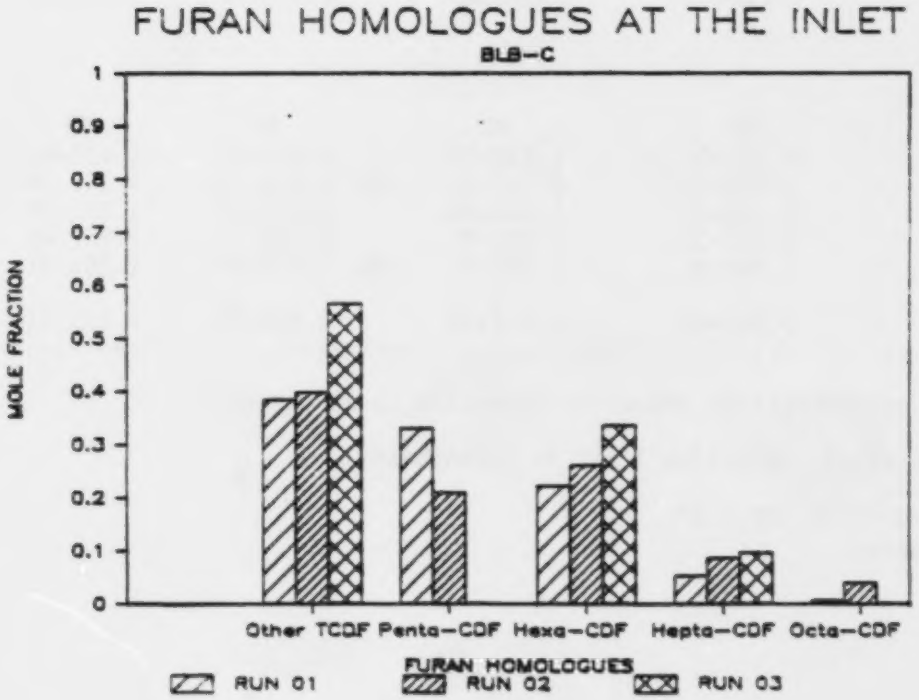


Figure 5-8. Homologue distribution at the ESP Inlet.

TABLE 5-10. DIOXIN/FURAN EMISSION FACTORS AT THE ESP INLET FOR SITE BLB-C

Dioxin/Furan Isomer	Dioxin/Furan Emission Factors (ug/kg)			
	Run 01	Run 02	Run 03	Avg.
DIOXINS				
2378 TCDD	NR	NR	NR	NR
Other TCDD	4.68E-03	2.02E-03	2.29E-03	3.00E-03
Penta-CDD	5.94E-03	2.98E-03	2.67E-03	3.87E-03
Hexa-CDD	9.18E-03	6.35E-03	6.49E-03	7.34E-03
Hepta-CDD	8.10E-03	4.91E-03	4.58E-03	5.86E-03
Octa-CDD	5.40E-03	4.04E-03	4.01E-03	4.48E-03
Total PCDD	3.33E-02	2.03E-02	2.00E-02	2.45E-02
FURANS				
2378 TCDF	NR	NR	NR	NR
Other TCDF	3.56E-02	3.94E-03	4.20E-03	1.46E-02
Penta-CDF	3.40E-02	2.31E-03	ND(2.48E-03)	1.21E-02
Hexa-CDF	2.52E-02	3.17E-03	3.05E-03	1.05E-02
Hepta-CDF	6.66E-03	1.15E-03	9.54E-04	2.92E-03
Octa-CDF	9.00E-04	5.77E-04	ND(5.73E-04)	4.92E-04
Total PCDF	1.02E-01	1.12E-02	8.21E-03	4.06E-02

ND = not detected (detection limit in parentheses).
ug = 1.0E-06g
8760 operating hours per year
NR = not reported

isomer per kilogram of black liquor fired on a dry solids basis. The average emission factors for total PCDD and total PCDF are 0.025 ug/kg and 0.041 ug/kg, respectively. Since the black liquor feed rates are consistent between test runs, the dioxin/furan emission factors have the same variability as the dioxin/furan concentrations.

5.4.2 Isomer and Homologue Specific Data at the ESP Outlet

Isomer and homologue specific emissions concentration data at the ESP outlet are summarized in Tables 5-11 and 5-12 for the three test runs. All other dioxin/furan isomers were detected at the outlet to ESP except for 2378-TCDD and 2378-TCDF. Run-specific data tables showing homologue emissions concentrations in both ng/dscm and parts-per-trillion units and homologue emissions rates in ug/hr units are included in Appendix D.

The relative distributions of the 2,3,7,8 TCDD/TCDF isomers and the tetra-through octa- PCDD/PCDF homologues are shown in Figure 5-9. For the dioxin homologues, octa-CDD accounted for 50 mole% of the homologues, followed by hepta-CDD at 30 mole% and hexa-CDD at 10%. Penta-CDD and other TCDD were about equal at 5% each. 2,3,7,8 TCDD was not detected. The furan homologues were about evenly distributed at 25% for TCDF, penta-CDF, hexa-CDF and hepta-CDF. 2,3,7,8 TCDF and octa-CDF accounted for about 5%.

Emission factors for the ESP outlet at Site BLB-C are shown in Table 5-13. The emission factors are reported as micrograms of isomer per kilogram of black liquor fired on a dry basis. The average emission factors are 0 ug/kg for 2,3,7,8 TCDD, 0.016 ug/kg for total PCDD and 0.008 ug/kg for total PCDF. The emission factors have the same variability as the dioxin/furan concentrations since black liquor feed rates were consistent between test runs.

5.4.3 Reduction of Dioxin/Furan Concentrations Due to the ESP.

The dioxin/furans which condense on particulate in the stack gas are removed from the stack gas along with the particulate by the pollution control device. The dioxin/furan removal efficiency of the control device is calculated from the difference of the inlet and outlet concentration of each dioxin/furan homologue divided by the inlet concentration of each homologue.

TABLE 5-11. SUMMARY OF DIOXIN/FURAN EMISSIONS DATA AT THE ESP OUTLET FOR SITE BLB-C

Dioxin/Furan Isomer	Isomer Concentration in Flue Gas (ng/dscm)			
	Run 01	Run 02	Run 03	Avg.
DIOXINS				
2378 TCDD	ND(9.57E-03)	ND(4.52E-03)	ND(2.51E-03)	.00E+00
Other TCDD	4.78E-02	1.24E-01	6.28E-02	7.84E-02
Penta-CDD	ND(2.39E-02)	2.49E-01	1.01E-01	1.16E-01
Hexa-CDD	7.18E-02	4.75E-01	2.39E-01	2.62E-01
Hepta-CDD	1.20E-01	1.38E+00	4.77E-01	6.59E-01
Octa-CDD	2.87E-01	2.71E+00	4.52E-01	1.15E+00
Total PCDD	5.26E-01	4.94E+00	1.33E+00	2.27E+00
FURANS				
2378 TCDF	ND(1.44E-02)	1.81E-02	ND(2.51E-03)	6.03E-03
Other TCDF	1.20E-01	2.99E-01	3.39E-01	2.52E-01
Penta-CDF	ND(4.78E-02)	2.49E-01	4.77E-01	2.42E-01
Hexa-CDF	1.20E-01	2.60E-01	5.15E-01	2.98E-01
Hepta-CDF	9.57E-02	3.85E-01	3.77E-01	2.86E-01
Octa-CDF	4.78E-02	4.52E-02	5.03E-02	4.78E-02
Total PCDF	3.83E-01	1.26E+00	1.76E+00	1.13E+00

NOTE: Isomer concentrations shown are at as-measured oxygen conditions.

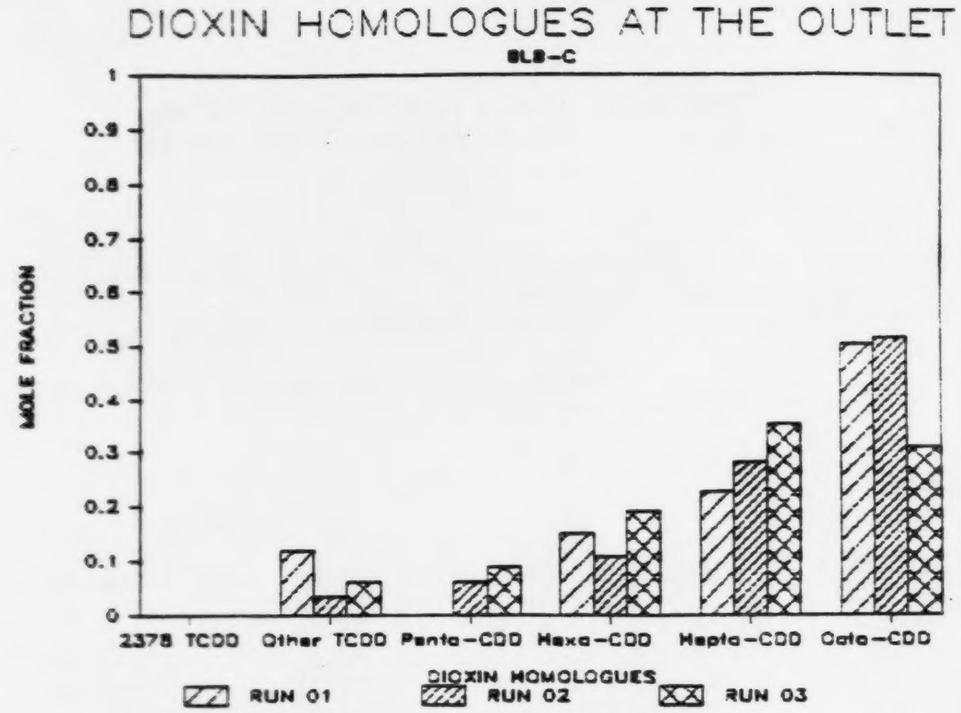
ND = not detected (detection limit in parentheses).
ng = 1.0E-09g
8760 operating hours per year

TABLE 5-12. SUMMARY OF DIOXIN/FURAN EMISSIONS DATA AT THE ESP OUTLET FOR SITE BLB-C (Concentrations Corrected to 3% Oxygen)

Dioxin/Furan Isomer	Isomer Concentration in Flue Gas (ng/dscm @ 3% oxygen)			
	Run 01	Run 02	Run 03	Avg.
DIOXINS				
2378 TCDD	ND(2.39E-02)	ND(3.90E-03)	ND(6.11E-03)	.00E+00
Other TCDD	1.20E-01	1.07E-01	1.53E-01	1.27E-01
Penta-CDD	ND(5.98E-02)	2.15E-01	2.44E-01	1.53E-01
Hexa-CDD	1.79E-01	4.10E-01	5.81E-01	3.90E-01
Hepta-CDD	2.99E-01	1.19E+00	1.16E+00	8.84E-01
Octa-CDD	7.18E-01	2.34E+00	1.10E+00	1.39E+00
Total PCDD	1.32E+00	4.27E+00	3.24E+00	2.94E+00
FURANS				
2378 TCDF	ND(3.59E-02)	1.56E-02	ND(6.11E-03)	5.21E-03
Other TCDF	2.99E-01	2.58E-01	8.25E-01	4.61E-01
Penta-CDF	ND(1.20E-01)	2.15E-01	1.16E+00	4.59E-01
Hexa-CDF	2.99E-01	2.25E-01	1.25E+00	5.92E-01
Hepta-CDF	2.39E-01	3.32E-01	9.17E-01	4.96E-01
Octa-CDF	1.20E-01	3.90E-02	1.22E-01	9.36E-02
Total PCDF	9.57E-01	1.08E+00	4.28E+00	2.11E+00

NOTE: Isomer concentrations shown are corrected to 3% oxygen.

ND = not detected (detection limit in parentheses).
ng = 1.0E-09g
8760 operating hours per year



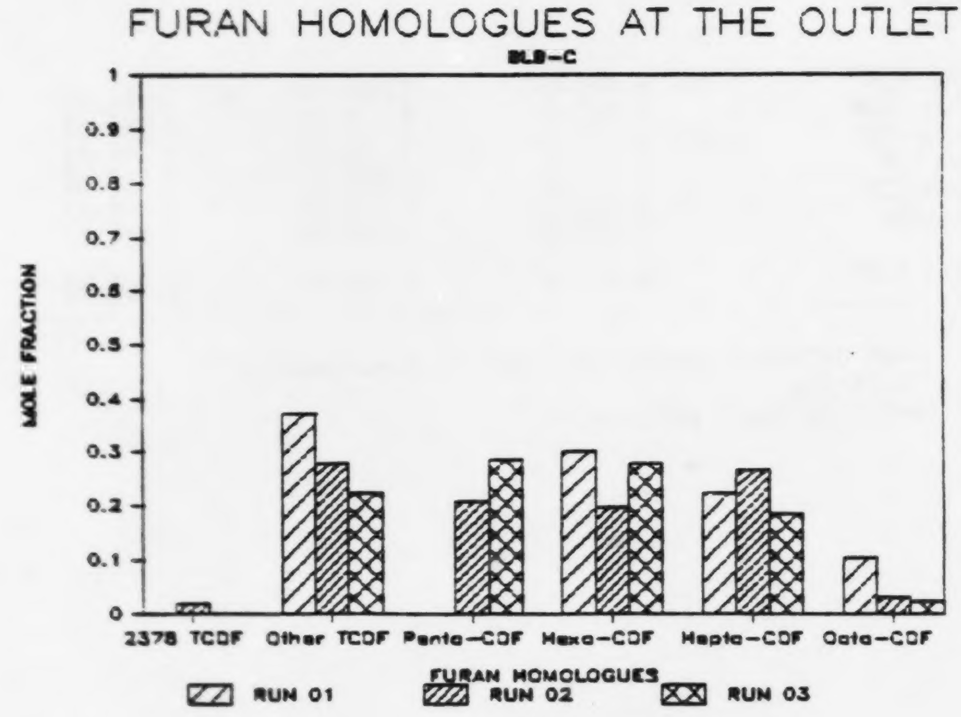


Figure 5-9. Dioxin and furan homologue distributions at the ESP Outlet at Site BLB-C.

TABLE 5-13. DIOXIN/FURAN EMISSION FACTORS AT THE ESP OUTLET FOR SITE BLB-C

Dioxin/Furan Isomer	Dioxin/Furan Emission Factors (ug/kg)			
	Run 01	Run 02	Run 03	Avg.
DIOXINS				
2378 TCDD	ND(6.33E-05)	ND(3.19E-05)	ND(1.76E-05)	.00E+00
Other TCDD	3.17E-04	8.78E-04	4.40E-04	5.45E-04
Penta-CDD	ND(1.58E-04)	1.76E-03	7.04E-04	8.20E-04
Hexa-CDD	4.75E-04	3.35E-03	1.67E-03	1.83E-03
Hepta-CDD	7.92E-04	9.73E-03	3.35E-03	4.62E-03
Octa-CDD	1.90E-03	1.91E-02	3.17E-03	8.07E-03
Total PCDD	3.48E-03	3.49E-02	9.33E-03	1.59E-02
FURANS				
2378 TCDF	ND(9.50E-05)	1.28E-04	ND(1.76E-05)	4.26E-05
Other TCDF	7.92E-04	2.11E-03	2.38E-03	1.76E-03
Penta-CDF	ND(3.17E-04)	1.76E-03	3.35E-03	1.70E-03
Hexa-CDF	7.92E-04	1.84E-03	3.61E-03	2.08E-03
Hepta-CDF	6.33E-04	2.71E-03	2.64E-03	2.00E-03
Octa-CDF	3.17E-04	3.19E-04	3.52E-04	3.29E-04
Total PCDF	2.53E-03	8.86E-03	1.23E-02	7.91E-03

ND = not detected (detection limit in parentheses).
ug = 1.0E-06g
8760 operating hours per year

Each value is considered to have an analytical uncertainty of ± 50%. An analysis of the uncertainty of the control device efficiency (contained in Appendix I) indicates that with a measured efficiency of greater than 66.7%, the removal efficiency is most likely positive. With measured efficiencies between 66.7% and -200%, a definite conclusion cannot be drawn concerning the true removal efficiency, and below -200%, the removal efficiency is most likely negative.

The measured ESP removal efficiencies for each dioxin/furan homologue at Site BLB-C are summarized in Table 5-14. In general, the average removal efficiencies for all the homologues indicate positive true removal efficiency for the ESP. However, some of the homologues had measured removal efficiencies in the inconclusive range.

5.5 BLACK LIQUOR PRECURSOR DATA

The strong black liquor fired in the Boiler BLB-C was analyzed for chlorinated benzenes, chlorinated phenols, and total chlorides. These compounds are believed to be dioxin/furan precursors which when present in the feed will aid in the formation of dioxin/furans during combustion.

Table 5-15 summarizes the results of the precursor analyses. Trace levels of penta chlorophenols were detected for Runs 02 and 03, but PCB's and CB's were not detected. The compound-specific dioxin precursor results are contained in Appendix C.

The average chlorides content of the black liquor was 3350 ppm. For Run 03, the total chlorides concentration was lower, which may be attributed to the substitution of microsul for vanillin black liquor in the liquor circuit.

The strong black liquor was not analyzed for total organic halogens (TOX). However, the fuel oil fired during Run 3 was analyzed and organic halogens were not detected.

5.6 HCl TRAIN CHLORIDE EMISSIONS DATA

Table 5-16 summarizes HCl train chloride emissions data measured at the ESP outlet sampling location. The data are reported as "front half," "back

TABLE 5-14. ESP REMOVAL EFFICIENCIES AT SITE BLB-C

Homologue	ESP Removal Efficiency, (%) Run 1	Run 2	Run 3	Average
Dioxins				
2378 TCDD	NR	NR	NR	NR
Other TCDD	93.2	86.0	80.4	86.5
Penta-CDD	100.0	81.0	73.2	84.7
Hexa-CDD	94.8	82.9	73.7	83.8
Hepta-CDD	90.2	35.7	25.6	50.5
Octa-CDD	64.6	-53.9	19.7	(10.1)[a]
Total PCDD	89.4	44.3	52.6	62.1
Furans				
2378 TCDF	NR	NR	NR	NR
Other TCDF	97.8	82.7	42.3	74.3
Penta-CDF	100.0	75.3	NR	87.6
Hexa-CDF	96.8	81.3	-20.2	(52.6)
Hepta-CDF	90.4	23.9	-182.2	(-22.6)
Octa-CDF	64.5	82.1	NR	73.3
Total PCDF	97.5	74.3	-52.9	(39.6)

NR = not reported.

[a] Values in parentheses ( ) indicate averages calculated from positive and negative values.

TABLE 5-15. SUMMARY OF DIOXIN PRECURSOR DATA FOR SITE BLB-C FEED SAMPLES

Precursor Categories	Precursor Concentration, ug/g (ppm)			
	Black Liquor Feed Samples			
	Run 1	Run 2	Run 3	Average
Total Chlorinated Benzenes	ND	ND	ND	ND
Total Chlorinated Biphenyls	ND	ND	ND	ND
Total Chlorinated Phenols	ND	trace[a]	0.01[a]	trace
Total Chlorides	3100	4760	2180	3350

[a] Only pentachlorophenol was detected in these samples.

ND = not detected.

TABLE 5-16. CHLORIDE CONCENTRATIONS AT THE OUTLET STACK FOR SITE BLB-C

Sample Component	Test Run	Emissions Concentration			Emissions Rate (kg/hr)
		mg/dscm	ppmv[a]	mg/dscm @ 3% O_2[b]	
Train Total	01	64.6	43.9	134.5	18.8
	02	138.4	94.0	281.5	37.5
	03	3952.8	2684.8	8132.8	1049.3
	Average[c]	101.5	68.9	208.0	28.2
Front Half	01	2.4	1.6	3.3	0.7
	02	10.7	7.3	21.8	2.9
	03	3.3	2.2	6.8	0.9
	Average	5.5	3.7	10.6	1.5
Back Half	01	62.3	42.3	85.5	18.1
	02	127.7	86.7	259.8	34.6
	03	3949.5	2682.6	8126.0	1048.4
	Average[c]	95.0	64.5	172.7	26.4

[a] ppmv = parts per million chloride by volume, dry basis at actual stack O_2 concentration

[b] Concentration corrected to 3% O_2 using the equation:

$$[Cl^-] @ 3\% O_2 = [Cl^-], \text{ as measured } \times (20.9-3)/(20.9-\%O_2)$$

where $\%O_2$ = oxygen concentration in stack gas as measured by Radian CEM system. See Table 5-5.

[c] Average does not include Run 03.

half," and "train total" chloride emissions. The front half emissions represent chlorides captured in the probe rinse/filter fraction of the HCl train, which may include metal chlorides contained in the particulate matter. The back half emissions represent chlorides captured in the HCl sample train impingers, which would include HCL and any metal chlorides that pass through the sample train filter. The train total emissions represent the sum of the front half and back half emissions.

The results indicate that about 95% of the chlorides were captured in the back half of the train. The total chlorides results for the back half of Run 03 are inconsistently high and are considered invalid. The Run 03 sample may have been contaminated. The average emissions concentration for Runs 01 and 02 were 100 mg of chlorides per dscm of flue gas which is equivalent to 70 ppmv of chlorides. In units which can be compared with other sites, chloride emissions were 200 mg/dscm @ 3% O_2 which is equivalent to 28 kg/hr. Compared with other Tier 4 test sites, the chlorides emissions for Site BLB-C are in the low range. For all test sites for which HCl sampling was performed, the chloride emissions ranged from 2.4 to 880 mg/dscm @ 3% O_2 (0.001 to 3.8 gr/dscf @ 3% O_2)

5.7 DIOXIN/FURAN RESULTS OF ESP ASH

The results of the dioxin/furan analyses of the ESP ash samples are summarized in Table 5-17. Low levels of octa-CDD, octa-CDF and hepta-CDF were detected in the ESP ash. The concentrations of the homologues that were detected are close to the minimum detection limits.

5.8 SOIL SAMPLING RESULTS

The soil sample was archived pending evaluation of analytical data.

TABLE 5-17. RESULTS OF DIOXIN/FURAN ANALYSIS OF ESP ASH SAMPLES AT SITE BLB-C

Homologue	Parts per billion (ppb) Run 1	Run 2	Run 3	Average
Dioxins				
All tetra-CDD	ND (0.02)	ND (0.01)	ND (0.01)	ND
Penta-CDD	ND (0.02)	ND (0.01)	ND (0.01)	ND
Hexa-CDD	ND (0.01)	ND (0.02)	ND (0.01)	ND
Hepta-CDD	ND (0.03)	ND (0.02)	ND (0.01)	ND
Octa-CDD	0.03	0.02	ND (0.03)	0.02
Total PCDD	0.03	0.02	ND	0.02
Furans				
All tetra-CDF	ND (0.04)	ND (0.05)	ND (0.02)	ND
Penta-CDF	ND (0.02)	ND (0.01)	ND (0.008)	ND
Hexa-CDF	ND (0.04)	ND (0.03)	ND (0.02)	ND
Hepta-CDF	ND (0.02)	ND (0.03)	0.01	ND
Octa-CDF	0.02	ND (0.01)	0.01	0.01
Total PCDF	0.02	ND	0.02	0.02

ND = not detected, minimum detection limit is shown in parenthesis.

6.0 SAMPLING LOCATIONS AND PROCEDURES

6.1 GASEOUS SAMPLING

Five types of gaseous samples were taken during this test program: Modified Method 5 (MM5), HCl, EPA Method 3, ambient XAD and continuous monitoring (CEM). The sampling locations and methods are further discussed in this section.

6.1.1 Gaseous Sampling Locations

6.1.1.1 Electrostatic Precipitator Outlet Exhaust Stack.

The electrostatic precipitator outlet exhaust stack sampling location is shown as point A in Figure 4-1. This location was used for dioxin/furan sampling and HCl sampling using MM5 procedures described in Section 6.1.2 and for continuous monitoring of O_2, CO, CO_2, NO_x, SO_2, and THC. Continuous monitoring was performed at this location rather than at the outlet from boiler BLB-C because the distance from the boiler outlet to any of the potential staging locations of the Radian instrument trailer was greater than the length of available heat traced sample line (i.e., greater than 200 feet) Gas velocity, molecular weight, and moisture were determined using EPA Methods 1 through 4.

At the ESP outlet stack location, four sampling ports were located around the circumference of the circular exhaust stack, which was surrounded by a rectangular sampling enclosure. A diagram of the exhaust stack and the sampling enclosure is shown in Figure 6-1. The orientation of the sample ports around the circumference of the stack is indicated in Figure 6-2. The distance from each port to the wall of the rectangular sampling enclosure is also shown in Figure 6-2.

The inside diameter of the stack at the plane of the sample ports was 4.3 m. (14 ft). The sample ports were located approximately 5.7 duct diameters from the nearest downstream flow disturbance, which was the electrostatic precipitator exhaust gas entrance to the stack. The distance

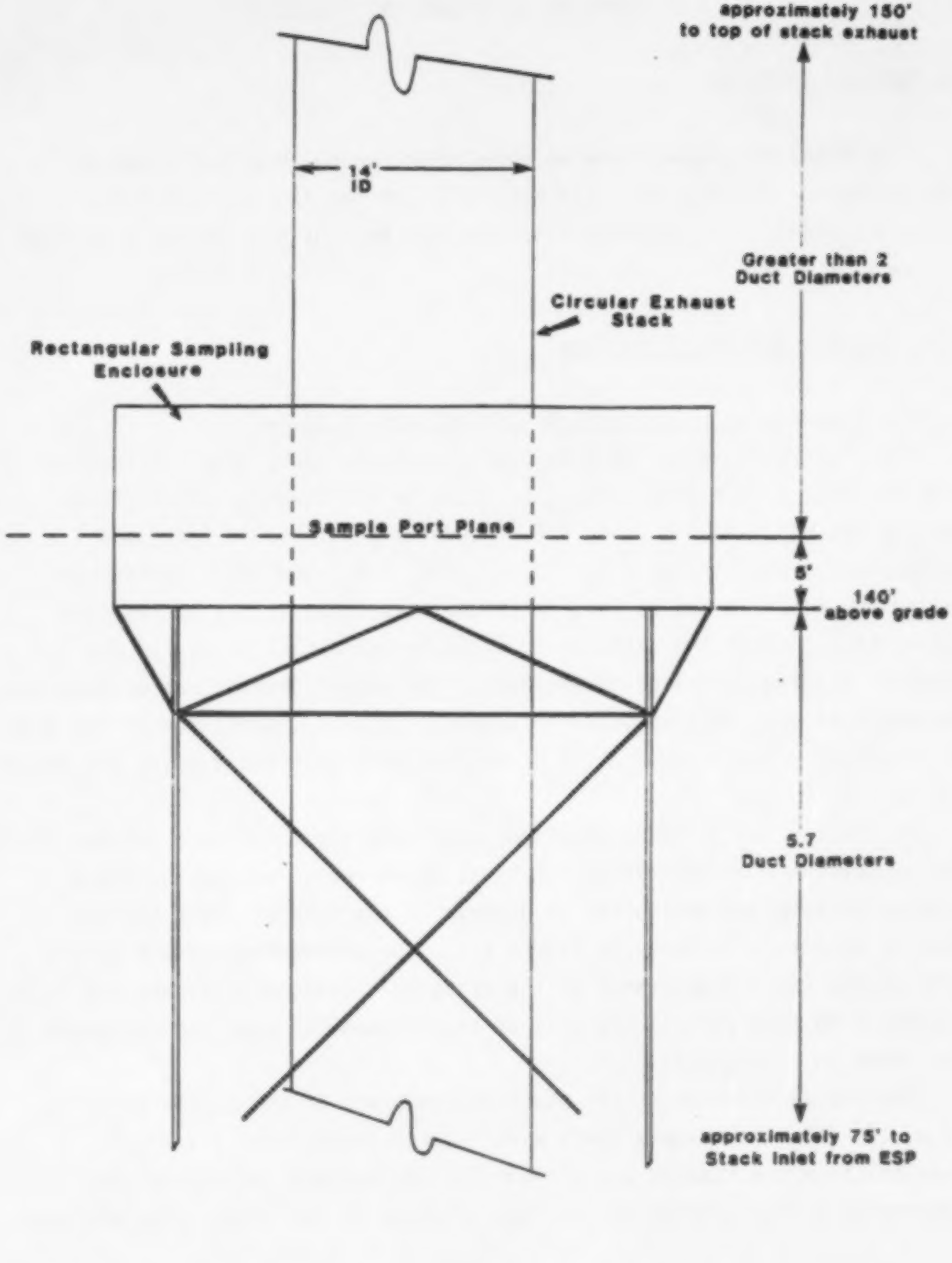

approximately 150'
to top of stack exhaust
14'
ID
Greater than 2
Duct Diameters
Circular Exhaust
Stack
Rectangular Sampling
Enclosure
Sample Port Plane
5'
140'
above grade
5.7
Duct Diameters
approximately 75' to
Stack Inlet from ESP

Figure 6-1. Electrostatic Precipitator Outlet Exhaust
Stack and Sampling Enclosure

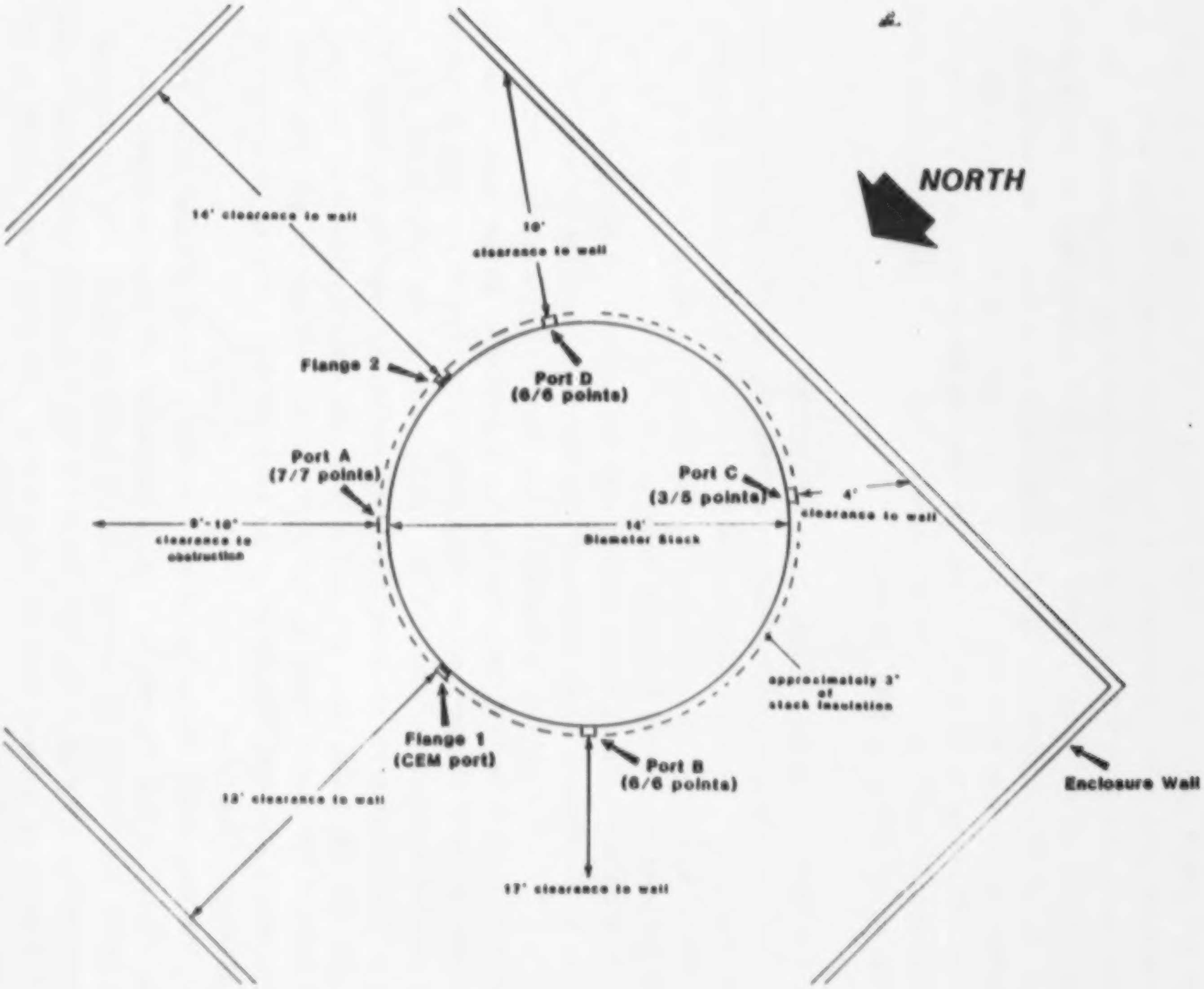

NORTH
14' clearance to wall
10'
clearance to wall
Flange 2
Port D
(6/6 points)
Port A
(7/7 points)
Port C
(3/5 points)
4'
clearance to wall
9'-10'
clearance to
obstruction
14'
Diameter Stack
approximately 3"
of
stack insulation
Flange 1
(CEM port)
Port B
(6/6 points)
Enclosure Wall
13' clearance to wall
17' clearance to wall

Figure 6-2. Electrostatic Precipitator Outlet Exhaust Stack Sampling Ports
(Site 08, BLB-C)

from the sample ports to the nearest upstream flow disturbance (top of stack) was greater than 2 duct diameters. A total of 24 traverse points were specified by EPA Method 2 for velocity determination at this location. Two sample probes of different lengths (4 ft and 10 ft.) were used at sample ports A, B, C, and D of Figure 6-2 to access the traverse points. The number of traverse points from each sample port is shown on Figure 6-2. Due to the limited clearance between Port C and the sampling enclosure, only 3 of the 5 traverse points at Port C could be reached. Thus, 22 of the 24 total traverse points were sampled at this location.

6.1.1.2 Electrostatic Precipitator Inlet Location.

The electrostatic precipitator inlet sampling location is shown as point B in Figure 4-1. This location was used for dioxin/furan sampling using MM5 procedures described in Section 6.1.2. Gas velocity, molecular weight, and moisture were determined using EPA Methods 1 through 4.

A diagram of the ductwork leading from the laminar air heaters (i.e., Boiler BLB-C exhaust) to the electrostatic precipitator inlet is shown in Figure 6-3. The ductwork consisted of two identical rectangular sections that direct approximately equal volumetric flowrates of boiler exhaust gas to the East and West chambers of the electrostatic precipitator. Each of the two rectangular ductwork sections had two sample ports on one side of the duct. Due to logistical problems associated with moving the sampling equipment between the two ducts, only the east side of the precipitator inlet ducting was sampled for dioxin/furan using the MM5 train. Volumetric gas flow rate measurements were obtained for both the east and west ducts to determine the relative gas flow rates.

The approximate distances of the electrostatic precipitator inlet duct sampling ports from the nearest flow disturbances are shown in Figure 6-4. Two ports were located on each half of the inlet ductwork. The ductwork was approximately 2.0 m (6.7 ft) wide and 4.1 m (13.6 ft) deep, with an equivalent duct diameter of approximately 2.7 m (9.0 ft). The ports were located on the narrow side of the duct, and were about 0.5 duct diameters from the nearest upstream flow disturbance (bend in duct) and 0.7 duct diameters from the

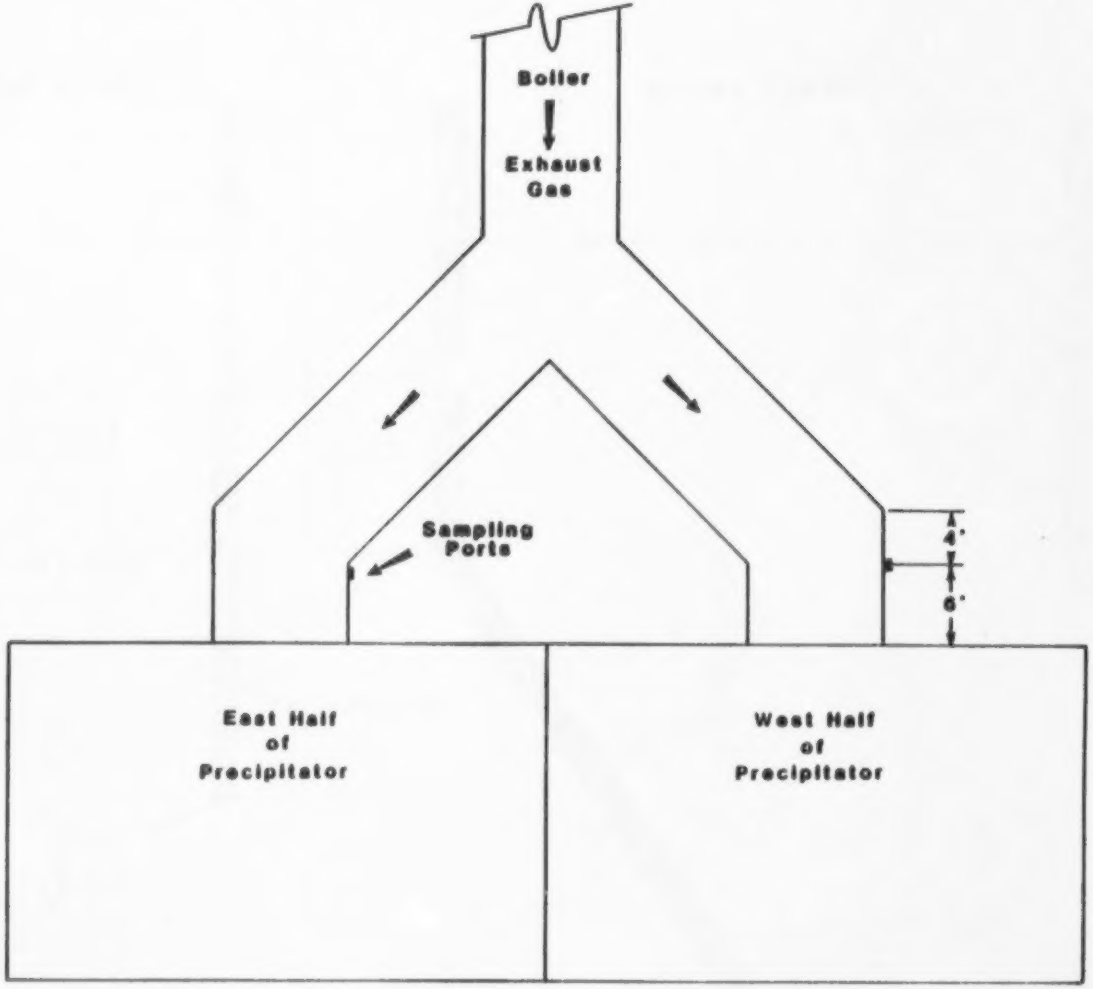

Boiler
Exhaust Gas
Sampling Ports
4'
6'
East Half of Precipitator
West Half of Precipitator

Figure 6-3. Electrostatic Precipitator Inlet Ductwork (Site 08, BLB-C)

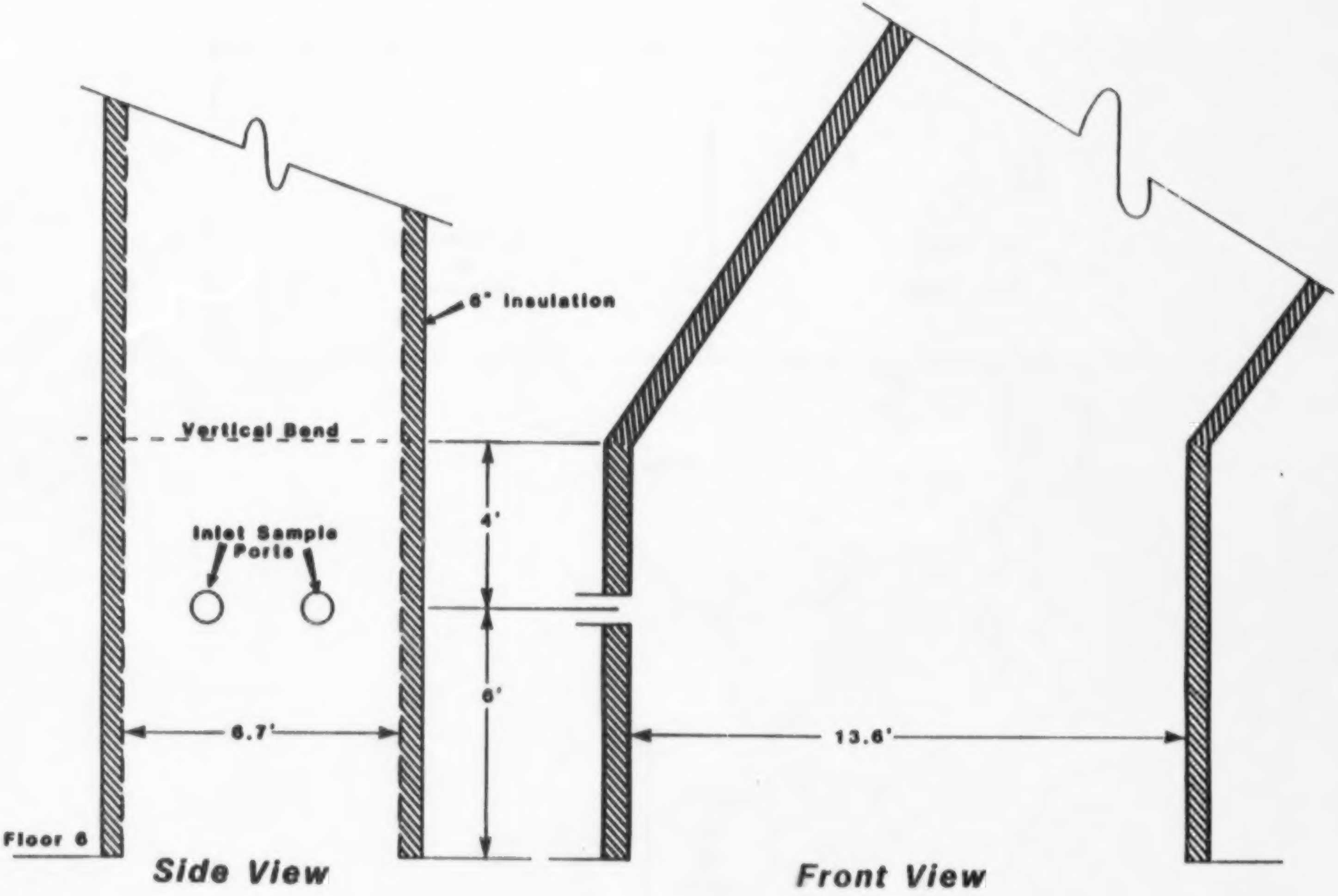

6" Insulation
Vertical Bend
Inlet Sample Ports
4'
6'
6.7'
13.6'
Floor 6
Side View
Front View

Figure 6-4. Electrostatic Precipitator Inlet East Sampling Ports (Site 08, BLB-C)

nearest downstream flow disturbance (ESP inlet). A total of 24 traverse points were specified by EPA Method 2 for velocity determination at this location. However, due to the location of the existing sample ports, the depth of the duct, and the breakage potential of glass probes longer than about 3.0 (10 ft), only 20 points were traversed for the MM5/dioxin sampling at the east duct and for the velocity determinations at both ducts. This was the maximum number of traverse points that could be accessed in the ducts using a conventional 10 foot probe/pitot assembly. The sampling approach was considered adequate for semi-quantitative determination of dioxin/furan concentrations and gas flow rates at this location.

6.1.1.3 Laminar Air Heater Ambient Air Intake Area.

Ambient air sampling was performed near the laminar air heater (LAH) air intake point using ambient XAD trains. The ambient XAD trains were stationed inside the recovery boiler building at the level of the LAH air intake point. Air entering the LAH's ultimately serves as combustion air for boiler BLB-C. Tramp air also enters the exhaust gas stream at this location. Based on oxygen monitoring data obtained by the host plant prior to the LAH's and CEM data obtained by Radian downstream of the LAH's, tramp air is estimated to account for as much as 50 percent of the exhaust gas stream at the MM5/ dioxin sampling locations.

6.1.2 Gaseous Sampling Procedures

Gaseous sampling procedures used during the testing at Site BLB-C are listed in Table 6-1. These procedures are discussed in detail in the Tier 4 Quality Assurance Project Plan (QAPP). A brief description of each method and any necessary deviations from the procedures outlined in the QAPP are provided in the following section.

6.1.2.1 Modified Method 5 (MM5).

Gas sampling for dioxins and furans was conducted according to the most current draft (October 1984) of the ASME chlorinated organic compound sampling protocol. This sampling method is a modified version of EPA Method 5 that

TABLE 6-1. SUMMARY OF GAS SAMPLING METHODS FOR SITE BLB-C

Sample Location	Sample Type or Parameter	Sample Collection Method
ESP outlet exhaust stack (Point A on Figure 4-1)	Dioxin/furan	Modified EPA Method 5
	Volumetric flow	EPA Method 2
	Molecular weight	EPA Method 3
	Moisture	EPA Method 4
	HCl	HCl Train
	CO, CO_2, O_2, SO_2, NO_x, and THC monitoring	Continuous monitors
ESP inlet (Point D on Figure 4-1)	Dioxin/furan	Modified EPA Method 5
	Volumetric flow	EPA Method 2
	Molecular weight	EPA Method 3
	Moisture	EPA Method 4
Laminar air heater air intake point	Ambient combustion air	Ambient XAD train

includes a solid sorbent module for trapping vapor phase organics. The MM5 sampling train was used to collect samples at the electrostatic precipitator outlet exhaust stack and at the electrostatic precipitator inlet location. A total of three MM5 test runs were conducted at the two sampling locations, with one test run being conducted per test day. The MM5/dioxin samples at the electrostatic precipitator outlet exhaust stack were collected isokinetically during 240 minute on-line sampling periods to provide sample train gas volumes ranging from 4.0 to 4.4 dscm (140 to 156 dscf). The MM5/dioxin samples at the electrostatic precipitator inlet ductwork were collected isokinetically during 200 minute on-line sampling periods to provide sample train gas volumes ranging from 3.1 to 3.2 dscm (110 to 114 dscf). Following sample recovery, the various components of the sample (filter, solvent rinses, sorbent trap, etc.) were sent to the EPA's Troika laboratories to quantify the 2,3,7,-TCDD, tetra- through octa- dioxin homologues, and tetra- through octa- furan homologues present in the samples.

A schematic diagram of the MM5 sampling train is shown in Figure 6-5. Flue gas is pulled from the stack through a nozzle and a heated glass probe. Particulate matter is removed from the gas stream by means of a glass fiber filter housed in a teflon-sealed glass filter holder maintained at 248 ± 25°F. The gas passes through a sorbent trap similar to that illustrated in Figure 6-6 for removal of organic constituents. The trap consists of separate sections for cooling the gas stream and for adsorbing the organic compounds on Amberlite XAD-2^R resin (XAD). A chilled impinger train following the sorbent trap is used to remove water from the flue gas, and a dry gas meter is used to measure the sample gas volume.

Modifications to the ASME protocol that were instituted for this test site include the following:

1. Sample recovery was modified to include water in the sample train rinsing scheme. Water, acetone, and methylene chloride were used in series to recover the probe, back half/coil, and first impinger samples. Previous black liquor boiler sampling experience has shown that water is necessary because the black liquor boiler particulate is soluble in water but insoluble in acetone.

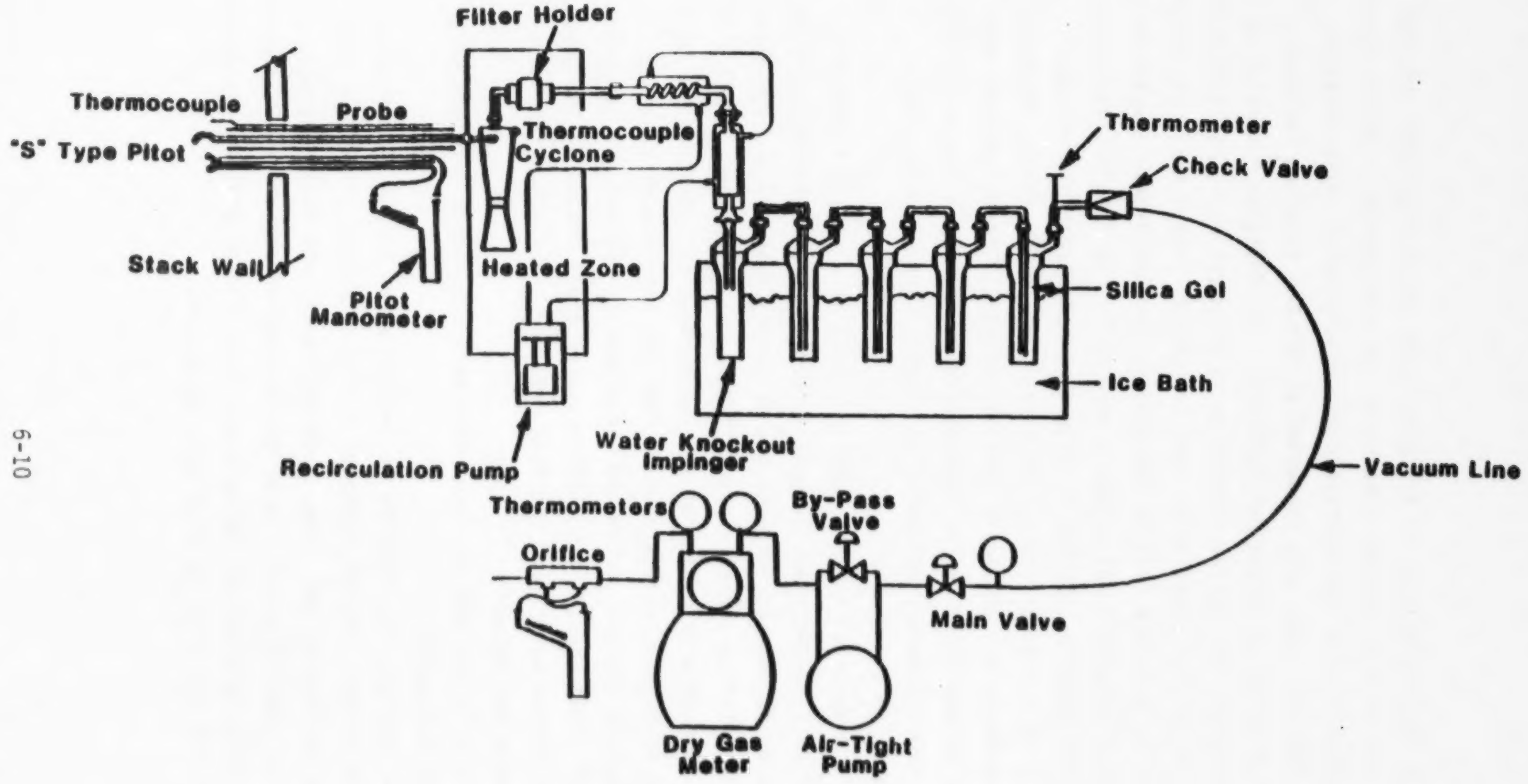

Filter Holder
Thermocouple
Probe
"S" Type Pitot
Thermocouple
Cyclone
Thermometer
Check Valve
Stack Wall
Heated Zone
Silica Gel
Pitot
Manometer
Ice Bath
Water Knockout
Impinger
Recirculation Pump
Vacuum Line
Thermometers
By-Pass
Valve
Orifice
Main Valve
Dry Gas
Meter
Air-Tight
Pump

Figure 6-5. Modified Method 5 Train

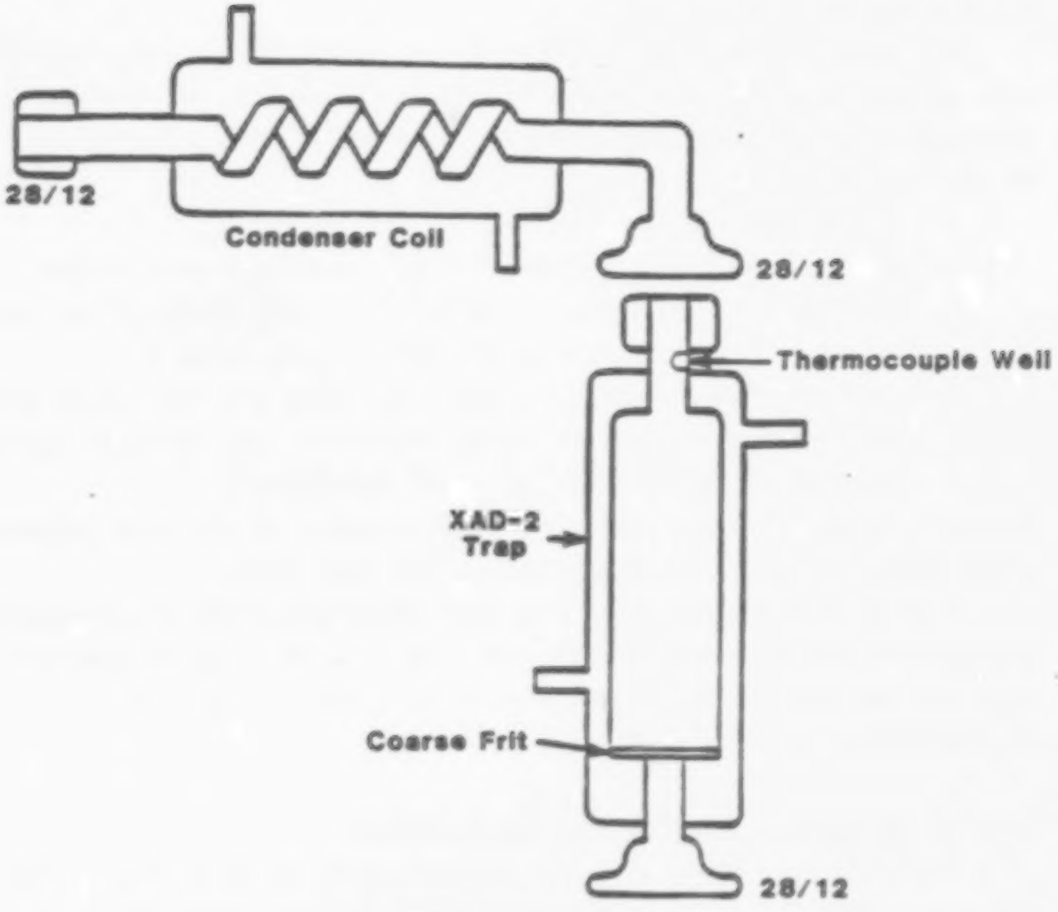

28/12
Condenser Coil
28/12
Thermocouple Well
XAD-2 Trap
Coarse Frit
28/12

Figure 6-6. Adsorbent Sampling System

2. The probe brush is specified in the ASME protocol as being inert material with a stainless steel handle. To ensure cleanliness, a separate nylon bristle brush attachable to a stainless steel handle was used for each probe cleaning.

6.1.2.2 HCL Determination.

HCl concentrations in the electrostatic precipitator outlet exhaust stack were determined using another modification of EPA Method 5. The sample train components and operation were identical to those of Method 5 with the following exceptions:

1. No knockout impinger was used.
2. Water in the first two impingers was replaced with 0.1M KOH.
3. Sampling was single point isokinetic with the nozzle placed at points in the stack with approximate average velocity.
4. The moisture/KOH in the impingers was saved for laboratory analysis by ion chromatography for total chlorides. The impinger catch was analyzed by Radian's Austin, Texas laboratory.

Recovery of the HCl train provided a sample consisting of three components: probe rinse, filter, and back-half rinse/impinger catch.

A total of three HCl train runs were performed at the electrostatic precipitator outlet stack sampling location. The HCl samples were collected over on-line sample times of 120 minutes at a sample flow rate of approximately 0.02 dscm (0.6 dscfm).

6.1.2.3 Volumetric Gas Flow Rate Determination

Volumetric gas flow rates were determined in conjunction with the MM5/dioxin sampling at the electrostatic precipitator inlet and outlet sampling locations using EPA Method 2. Based on this method, the volumetric gas flow rates was determined by measuring the average velocity of the flue gas and the cross-sectional area of the duct. The average flue gas velocity was calculated from the average gas velocity pressure across an S-type pitot tube, the average flue gas temperature, the wet molecular weight, and the absolute static pressure.

6.1.2.4 Flue Gas Moisture Determination.

The moisture content of the flue gas was determined at the electrostatic precipitator inlet and outlet sampling locations using EPA Method 4. Based on this method, a measured volume of particulate-free gas was pulled through a chilled impinger train. The quantity of condensed water was determined gravimetrically and then related to the volume of gas sampled to determine the moisture content.

6.1.2.5 Flue Gas Molecular Weight Determination.

The integrated sampling techniques described in EPA Method 3 was used at the electrostatic precipitator inlet and outlet sampling locations to obtain a composite flue gas sample for fixed gas (O_2, CO_2, N_2) analysis. The fixed gas analysis was used to determine the molecular weight of the gas stream. A small diaphragm pump and a stainless steel probe were used to extract single point flue gas samples. The samples were collected in a Tedlar^R bag. Moisture was removed from the gas sample by a water-cooled condenser so that the fixed gas analysis was on a dry basis.

The composition of the gas sample was determined using a Shimadzu Model 3BT analyzer instead of the Fyrite or Orsat analyzer prescribed in EPA Method 3. The Shimadzu instrument employs a gas chromatograph and a thermal conductivity detector to determine the fixed gas composition of the sample.

6.1.2.6 Continuous Monitors.

Continuous monitoring was performed at the electrostatic precipitator outlet sampling location for O_2, CO_2, CO, NO_x, SO_2, and THC throughout the 4 to 6-hour period that MM5 dioxin sampling was being conducted each test day. The primary objectives of the continuous monitoring were to observe fluctuations in flue gas parameters and to provide an indication of combustion conditions. Sample acquisition was accomplished using an in-stack filter probe and a 150 ft length of heat-traced Teflon^R sample line connected to a mobile laboratory. The heat-traced sample line was maintained at a temperature of at least 120°C (250°F) to prevent condensation in the sample line. The stack gas sample was drawn through the in-stack filter and heat-traced sample line using pumps located in the mobile laboratory. Sample gas to be analyzed for CO, CO_2, O_2, SO_2, and NO_x was pumped through a sample gas conditioner, which consisted of an ice bath and knockout trap. The sample gas conditioner removes moisture and thus provides a dry gas stream for analysis. A separate unconditioned gas stream was supplied to the THC analyzer for analysis on a wet basis.

An Anarad Model 412 non-dispersive infrared (NDIR) analyzer was used to measure CO and CO_2; a Beckman Model 755 paramagnetic analyzer was used to measure O_2; a Teco Model 10 chemiluminescent analyzer was used to measure NO_x: a Teco Model 40 pulsed fluorescence analyzer was used to measure SO_2; and a Beckman Model 402 flame ionization analyzer was used to measure THC.

6.2 LIQUID SAMPLING

Several types of liquid samples were obtained during this test program: strong black liquor, white liquor, weak black liquor, vanillin black liquor and make-up water. The corresponding sampling locations are shown on Figure 4-1 as points C, H, G, F and K, respectively. During Run 3, microsul and fuel oil were also sampled.

6.2.1 Strong Black Liquor Sampling

Strong black liquor samples were taken during each run directly from the feed guns that introduce the liquor into the boiler. The host site performs periodic liquor sampling at this location for solids content analysis. A dipper-type sampler was used by plant personnel to obtain hourly strong black liquor samples during the test program.

Three identical composite strong black liquor samples were obtained during each of the three tests: a 1 liter composite for dioxin/furan analysis. another 1-liter composite for dioxin precursor analysis, and a 125 ml composite for total chlorine analysis. The composite strong black liquor samples for each run were comprised of hourly grab samples from the feed guns. It was necessary to heat the running hourly sample composite to prevent the sample from solidifying prior to taking the final sample aliquots. This was accomplished by wrapping the sample composite bottle with rubber-coated heat tape.

6.2.2 Fuel Oil Sampling

Fuel oil samples were taken only during Run 03, since no fuel oil was fired during Runs 01 and 02. The samples were taken twice during the run by plant personnel, using a tap valve in the fuel oil transfer line.

Three identical 125 ml composite fuel oil samples were prepared: one sample was for dioxin/furan analysis, one sample for dioxin precursor analysis, and one sample for total chlorine analysis.

6.2.3 Auxiliary Black Liquor Circuit Sampling

Samples of white liquor, weak black liquor, vanillin black liquor, microsul, make-up water and caustic were obtained during some or all of the test runs to indicate the relative amounts of chlorine entering the black liquor circuit through various input sources. One 125 ml composite sample of each stream was obtained during each test. Individual samples were taken twice during each test run, and the composite samples were prepared accordingly. The samples were analyzed for total chlorine content only. The chlorine-content data were used in conjunction with mass flow data to determine the relative amounts of chlorine associated with each potential source of chlorine input to the black liquor circuit.

White liquor, weak black liquor, and make-up water samples were taken twice during each test run. The white liquor samples were taken from a short-term storage tank using a dipper-type sample. Weak black liquor samples were taken from a sample tap in a section of the weak black liquor transfer line upstream of the vanillin black liquor mix point. Make-up water samples were taken directly from spray nozzles on the pulp washer line.

Vanillin black liquor samples were taken only during Runs 01 and 02, since no vanillin black liquor was being added to the liquor circuit during Run 03. These samples were taken from a sample tap in the vanillin black liquor transfer line.

Microsul samples were taken only during Run 03, since no microsul was being added to the liquor circuit during Runs 01 and 02. The microsul samples were taken from a sample tap in the microsul transfer line.

6.3 SOLID SAMPLING

Three types of solid samples were obtained at Site BLB-C: electrostatic precipitator catch, make-up lime, and soils from plant property. The sampling locations and methods are discussed below.

6.3.1 Electrostatic Precipitator Catch Sampling

Samples of electrostatic precipitator catch were obtained twice during each test run from the screw conveyor serving the precipitator. Approximately 250 grams of dry catch were obtained at the beginning and end of each test run. The two samples were composited in a 950 ml bottle at the end of the test run and submitted for dioxin/furan analysis.

6.3.2 Make-up Lime Sampling

Samples of make-up lime were obtained twice during each run to determine the amount of chloride entering the liquor circuit with the make-up lime. Approximately 250 grams of pebble lime were obtained at the beginning and each of each test run. The two samples were composited at the end of the test run. and a portion of the sample was submitted for total chloride analysis.

6.3.3 Soil Sampling

A single composite soil sample comprised of 10 individual soil samples was obtained at Site BLB-C. Soil sampling protocol for Tiers 3, 5, 6, and 7 of the National Dioxin Study are specified in the document, "Sampling Guidance Manual for the National Dioxin Study." A similar protocol was used for soil sampling at this test site. A total of 10 soil sampling locations were selected on plant property surrounding the black liquor/power complex. The 10 individual soil sampling locations are shown in Figure 6-7. Soil samples were collected by forcing a bulb planter into the soil to a depth of 3 inches. The

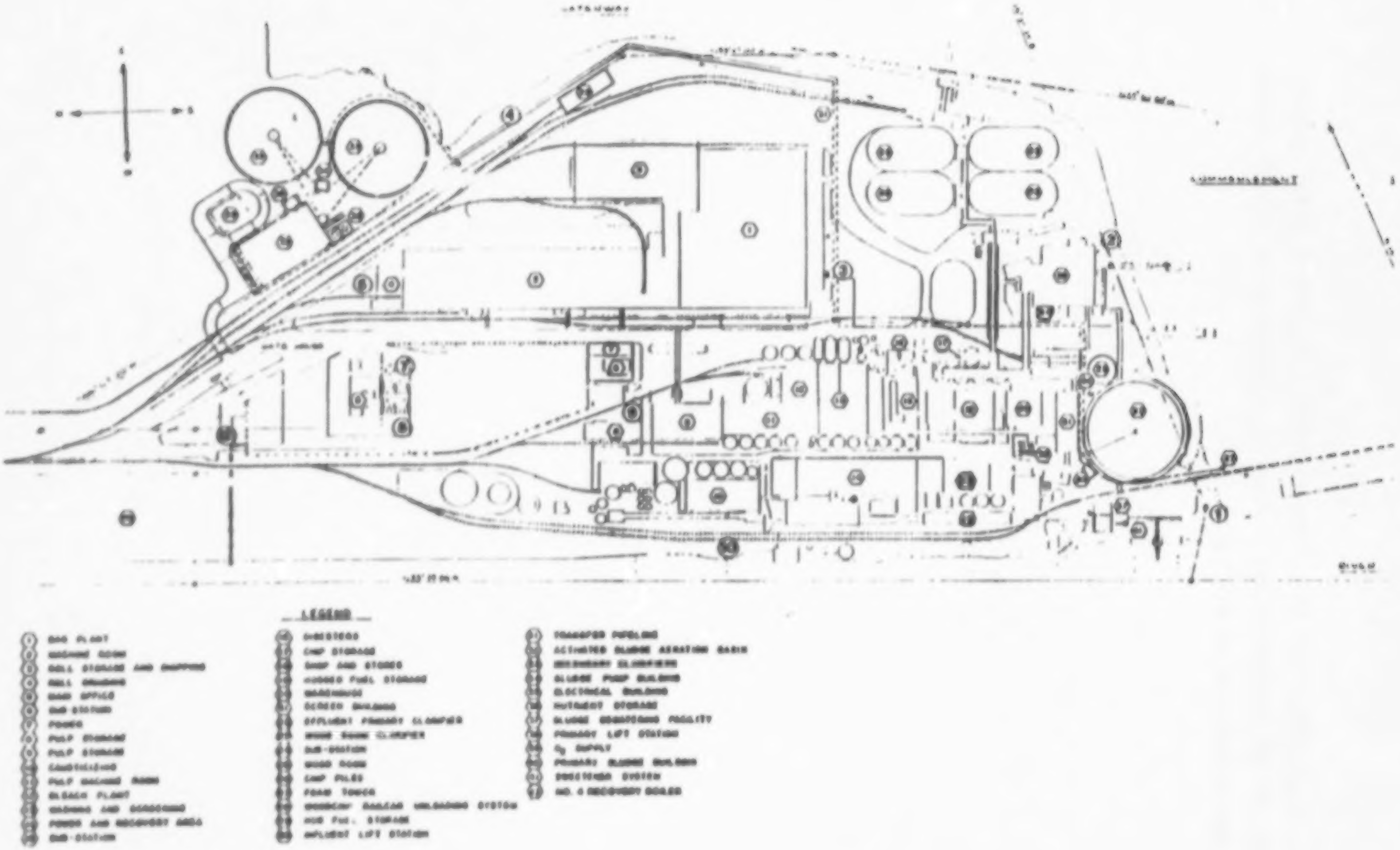

LEGEND
BAG PLANT
MACHINE ROOM
ROLL STORAGE AND SHIPPING
ROLL GRADING
MAIN OFFICE
SUB STATION
PONDS
PULP STORAGE
PULP STORAGE
CAUSTICIZING
PULP MACHINE ROOM
BLEACH PLANT
WASHING AND SCREENING
POWER AND RECOVERY AREA
SUB-STATION
DIGESTERS
CHIP STORAGE
SHOP AND STORES
HOGGED FUEL STORAGE
WAREHOUSE
SCREEN BUILDING
EFFLUENT PRIMARY CLARIFIER
WOOD ROOM CLARIFIER
SUB-STATION
WOOD ROOM
CHIP PILES
FOAM TOWER
OVERHEAD RAILCAR UNLOADING SYSTEM
HOG FUEL STORAGE
INFLUENT LIFT STATION
TRANSFER PIPELINE
ACTIVATED SLUDGE AERATION BASIN
SECONDARY CLARIFIERS
SLUDGE PUMP BUILDING
ELECTRICAL BUILDING
NUTRIENT STORAGE
SLUDGE DEWATERING FACILITY
PRIMARY LIFT STATION
O_2 SUPPLY
PRIMARY SLUDGE BUILDING
[illegible] SYSTEM
NO. 4 RECOVERY BOILER

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Figure 6-7. Soil Sampling Locations

soil samples were then composited in a Tier 4 cleaned stainless steel bucket. Five hundred grams of the composite was placed in a 950 ml glass amber bottle and returned to Radian/RTP for archiving.

7.0 ANALYTICAL PROCEDURES

Laboratory procedures used to quantify dioxins/furans and dioxin/furan precursors in the Tier 4 samples are described in this section. Analyses for dioxins/furans were performed by EPA's Troika laboratories. The procedures used for these analyses are described in detail in the Analytical Procedures and QA Plan for the Analysis of Tetra through Octa CDD's and CDF's in Samples from Tier 4 Combustion and Incineration Processes (addendum to EPA/600/3-85/019, April 1985).

Black liquor boiler feed samples from Site BLB-C were analyzed to determine concentrations of chlorinated phenols (CP), chlorobenzenes (CB), polychlorinated biphenyls (PCB's), total organic halogen (TOX), and total chlorine. Procedures used for these analyses are detailed in Section 7.2.

7.1 DIOXINS/FURANS

The analytical procedures described in this section were used for the determination of PCDD and PCDF in stack effluent samples (MM5). Samples consisting of organic solvents, aqueous solutions and solids were prepared for analysis using slightly different procedures. The organic solvent samples consisted of rinses from the MM5 probe, nozzle, filter housing and condenser coil. Aqueous solutions consisted of impinger catch and solid samples including filters, and XAD resin. Isotopically-labeled surrogate compounds were added to all samples prior to extraction to allow determination of method efficiency and for quantification purposes.

Organic liquid samples (acetone and hexane or methylene chloride) were concentrated using a nitrogen blowdown apparatus. The residue, which contained particulates from the train probe and nozzle, was combined with the filter and handled as a solid sample. Solid samples were extracted with benzene in a Soxhlet apparatus for a period of at least 16 hours. The sample was then concentrated by nitrogen blowdown and subjected to chromatographic cleanup procedures.

Aqueous solutions were extracted with hexane by vigorous shaking for a three hour period. This extraction procedure was repeated three times, with the organic fractions ultimately being combined and concentrated for chromatographic cleanup.

The cleanup procedure involved using liquid chromatographic columns to separate the compounds of interest from other compounds present in the samples. Four different types of columns were used: a combination acid and base modified silica gel column, a basic alumina column, a PX-21 carbon/celite 545 column and a silica/diol micro column. These were used in successive steps, with the last two being used only if necessary.

The cleaned samples were analyzed using high resolution gas chromatography/high resolution mass spectrometry (GC/MS). Conditions for the analyses were as follows:

Gas Chromatograph - Injector configured for capillary column, splitless injection; injector temperature 280°C; helium carrier gas at 1.2 ml/min; initial column temperature 100°C: final column temperature 240°C; interface temperature 270°C.

Mass Spectrometer - Varian/MAT Model 311A; electron energy 70ev; filament emission 1MA; mass resolution 8,000 to 10,000; ion source temperature 270°C.

7.2 DIOXIN/FURAN PRECURSORS

Feed samples for Site BLB-C were analyzed by Radian/RTP for chlorophenols (CP), chlorobenzenes (CB) and polychlorinated biphenyls (PCB's) by GC/MS; and total chlorine by Parr Bomb combustion followed by ion chromatography. Analytical procedures are discussed in the following sections.

7.2.1 GC/MS Analyses

The analytical procedures used for determining CP, CB, and PCB concentrations in feed samples are modified versions of procedures typically used for the analysis of MM5 train components.

7.2.1.1 Sample Preparation

A flow chart for the sample preparation procedure used for Site BLB-C feed samples is shown in Figure 7-1. The first step involved adding 200 mL of

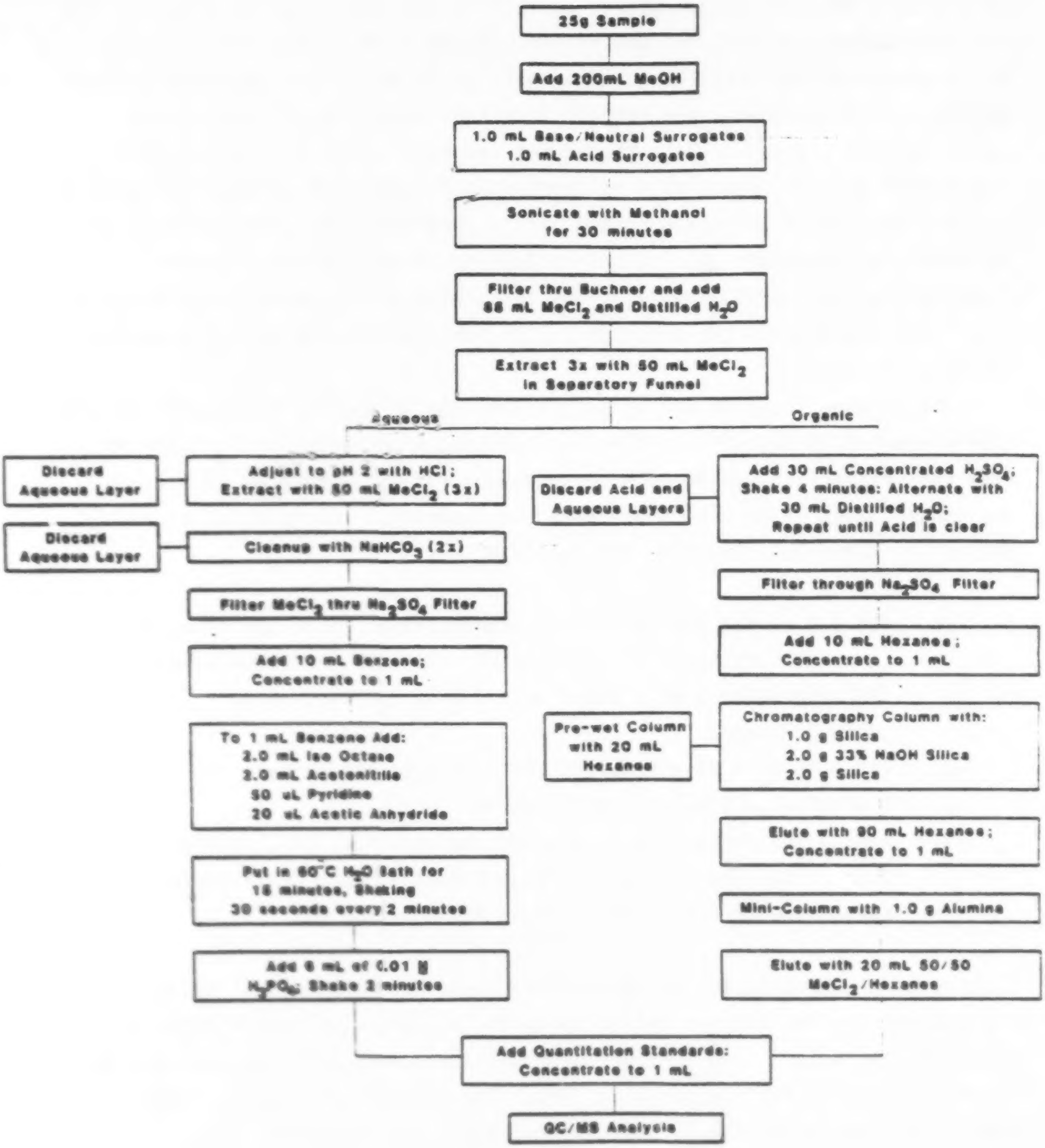
25g Sample
Add 200mL MeOH
1.0 mL Base/Neutral Surrogates
1.0 mL Acid Surrogates
Sonicate with Methanol for 30 minutes
Filter thru Buchner and add 85 mL $MeCl_2$ and Distilled H_2O
Extract 3x with 50 mL $MeCl_2$ in Seperatory Funnel
Aqueous
Organic
Discard Aqueous Layer
Adjust to pH 2 with HCl; Extract with 50 mL $MeCl_2$ (3x)
Discard Aqueous Layer
Cleanup with $NaHCO_3$ (2x)
Filter $MeCl_2$ thru Na_2SO_4 Filter
Add 10 mL Benzene; Concentrate to 1 mL
To 1 mL Benzene Add:
2.0 mL Iso Octane
2.0 mL Acetonitrile
50 uL Pyridine
20 uL Acetic Anhydride
Put in 60°C H_2O Bath for 15 minutes, Shaking 30 seconds every 2 minutes
Add 5 mL of 0.01 N H_3PO_4; Shake 2 minutes
Discard Acid and Aqueous Layers
Add 30 mL Concentrated H_2SO_4; Shake 4 minutes: Alternate with 30 mL Distilled H_2O; Repeat until Acid is clear
Filter through Na_2SO_4 Filter
Add 10 mL Hexanes; Concentrate to 1 mL
Pre-wet Column with 20 mL Hexanes
Chromatography Column with:
1.0 g Silica
2.0 g 33% NaOH Silica
2.0 g Silica
Elute with 90 mL Hexanes; Concentrate to 1 mL
Mini-Column with 1.0 g Alumina
Elute with 20 mL 50/50 $MeCl_2$/Hexanes
Add Quantitation Standards: Concentrate to 1 mL
GC/MS Analysis

Figure 7-1. Sample preparation flow diagram for Site BLB-C precursor analyses

methanol to the sample. The next step in the procedure involved adding labeled surrogate compounds to provide a measure of extraction method efficiency. The next step involved sonicating the sample for 30 minutes. The sonicated sample was filtered and rinsed with 85 mL $MeCl_2$ and distilled H_2O. The filtrate was extracted three times with 50 mL $MeCl_2$ in a separatory funnel and the resulting aqueous and organic fractions saved for derivatization and/or further cleanup. These procedures involve initial extraction of the sample with an appropriate solvent, preliminary separation of the compounds of interest by solvent partitioning and liquid chromatography, and analysis of the processed fractions. Solutions containing CB and PCB are injected directly into the GC/MS, and solutions containing CP are derivatized prior to injection. Details on the procedures used for Site 05 samples are provided in the sections below.

The aqueous fraction (or acids portion) was acidified to pH2 with HCl and then extracted three times with $MeCl_2$, then two times with $NaHCO_3$. The $MeCl_2$ from this extraction was dried with anhydrous Na_2SO_4, exchanged to benzene, and concentrated using a nitrogen blowdown apparatus. Acetylation of any CP present in the sample involved the following steps:

1. Add 2.0 mL iso-octane, 2.0 mL acetonitrile, 50 uL pyridine, and 20 uL acetic anhydride to the extract. Put the test tube containing the extract in a $60^{o}C$ water bath for 15 minutes, shaking 30 seconds every 2 minutes.
2. Add 6 mL of 0.01 N H_3PO_4 to the test tube and agitate the sample for 2 minutes on a wrist action shaker.
3. Remove the organic layer and add the quantitation standard. Concentrate the sample in a Reacti-Vial at room temperature (using prepurified N_2) to 1 mL prior to GC/MS analysis.

Cleanup of the organic (or base/neutrals) layer from the initial $MeCl_2$ extraction involved successively washing the extract with concentrated H_2SO_4 and deionized water. The acid or water was added in a 30 mL portion and the sample was shaken for two minutes. After the aqueous and organic layers were completely separated, the aqueous or acid layer was discarded.

The acid washing procedure was repeated until the acid layer was colorless. The sample was then dried with anhydrous Na_2SO_4, exchanged into hexanes and concentrated. Final cleanup of the sample by column chromatography involved the following procedure.

A glass macro-column, 20 mm o.d. x 230 mm in length, taper to 6 mm o.d. on one end was prepared. The column was packed with a plug of silanized glass wool, followed successively by 1.0 g silica, 2.0 g silica containing 33% (w/w) 1 M NaOH, and 2.0 g silica. The concentrate was quantitatively transferred to the column and eluted with 90 mL hexanes. The entire eluate was collected and concentrated to a volume of 1 mL in a centrifuge tube, as above.

A disposable liquid chromatography mini-column was constructed by cutting off a 5-mL Pyrex disposable pipette at the 2.0 mL mark and packing the lower portion of the tube with a small plug of silanized glass wool, followed by 1 g of Woehlm basic alumina, which has been previously activated for at least 16 hours at 600^0C in a muffle furnace and cooled in a desiccator for 30 minutes just before use. The concentrated eluate from above was quantitatively transferred onto the liquid chromatography column, and the centrifuge tube was rinsed consecutively with two 0.3-mL portions of a 3 percent $MeCl_2$:hexanes solution, and the rinses were transferred to the chromatography column.

The column was eluted with 20 mL of a 50 percent (v/v) $MeCl_2$:hexanes, and the elute was retained. The retained fraction was concentrated to a volume of approximately 1 mL by heating the tubes in a water bath while passing a stream of prepurified N_2 over the solutions. The quantitation standard was added and the final volume was adjusted to 1.0 mL prior to GC/MS analysis.

7.2.1.2 Analysis

Analyses for CP, CB and PCBs present in the feed sample extracts were performed using a Finnigan Model 5100 mass spectrometer using selected ion monitoring. A fused silica capillary column was used for chromatographic separation of the compounds of interest. Analytical conditions for the GC/MS analysis are shown in Table 7-1.

Tuning of the GC/MS was performed daily as specified in the Tier 4 QA Project Plan. An internal standard calibration procedure was used for sample quantitation. Compounds of interest were calibrated against a fixed

TABLE 7-1. INSTRUMENT CONDITIONS FOR GC/MS PRECURSOR ANALYSES

	Chlorobenzenes/ Polychlorinated biphenyls	Chlorophenols
Column	30 m WB DB-5 (1.0 u film thickness) fused silica capillary	
Injector Temperature	290°C	290°C
Separator Oven Temperature	290°C	290°C
Column Head Pressure	9 psi	9 psi
He flow rate	1 mL/min	1 mL/min
GC program	40(4)-290°C, 10°/min & hold	40(1)-290°C, 12°/min & hold
Emission Current	0.50 ma	0.50 ma
Electron Energy	70 ev	70 ev
Injection Mode	Splitless 0.6 min, then 10:1 split	
Mode	Electron ionization, Selected Ion Monitoring	

concentration of either d_{12}-chrysene (CB, PCB) or d_8-naphthalene (CP). Compounds of the calibration solution are shown in Table 7-2. For multi-point calibrations, this solution was injected at levels of 10, 50, 100, and 150 ng/mL.

Compound identification was confirmed by comparison of chromatographic retention times and mass spectra of unknowns with retention times and mass spectra for reference compounds. Since the selected ion monitoring technique was necessary for the types of samples analyzed, care was taken to monitor a sufficiently wide mass region to avoid the potential for reporting false positives.

The instrument detection limit was estimated to be approximately 500 picograms on column. For a 50 g sample and 100 percent recovery of the analyte, this corresponds to a feed sample detection limit of 10 ppb.

7.3 TOX ANALYSIS

Boiler feed samples were analyzed for total organic halide (TOX) by short-column GC and a Hall detector (GC/Hall). Samples were extracted with benzene for at least 16 hours in a Soxhlet apparatus. The extracts were washed three times with 100 mL portions of reagent-grade water concentrated to 10 mL.

An attempt to use a fused silica capillary column to separate surrogates from target compounds was unsuccessful due to the complexity of the sample constituents. Determinations for TOX were therefore performed on samples without surrogates and no measure of extraction efficiency is available.

Instrument conditions are shown in Table 7-3. Sample quantitation was based on an average response factor developed from a mixture of chlorinated benzenes and brominated biphenyls. Individual CP, CB and PCB's were also injected at various concentrations to develop a calibration curve for comparison to the mixture response factors.

7.4 TOTAL CHLORINE ANALYSIS

Total chlorine concentrations in feed samples were determined by Parr Bomb combustion followed by ion chromatography (IC). A 0.5 g sample was

TABLE 7-2. COMPONENTS OF THE CALIBRATION SOLUTION

Base/Neutrals	Acids
4-chlorobiphenyl	2,5-dichlorophenol
3,3'-dichlorobiphenyl	2,3-dichlorophenol
2,4',5-trichlorobiphenyl	2,6-dichlorophenol
3,3'4,4'-tetrachlorobiphenyl	3,5-dichlorophenol
2,2',6,6'-tetrachlorobiphenyl	3,4-dichlorophenol
2,2,4,5,6-pentachlorobiphenyl	2,3,5-trichlorophenol
2,2',4,4',5,5'-hexachlorobiphenyl	2,3,6-trichlorophenol
2,2',3,4,4',5',6-heptachlorobiphenyl	3,4,5-trichlorophenol
2,2',3,3',4,4',5,5'-octachlorobiphenyl	2,4,5-trichlorophenol
2,2',3,3',4,4',5,6,6'-nonachlorobiphenyl	2,3,4-trichlorophenol
decachlorobiphenyl	2,3,5,6-tetrachlorophenol
p-dichlorobenzene	pentachlorophenol
1,2,4-trichlorobenzene	d_6-phenol (SS)
1,2,3,5-tetrachlorobenzene	d_4-2-chlorophenol (SS)
pentachlorobenzene	$^{13}C_6$-pentachlorophenol (SS)
hexachlorobenzene	d_8-naphthalene (QS)
d_4-1,4-dichlorobenzene (SS)[1]	2,4,6-tribromophenol (QS)
3-bromobiphenyl (SS)	d_{10}-phenanthrene (QS)
2,2',5,5'-tetrabromobiphenyl (SS)	d_{12}chrysene (QS)
2,2',4,4',6,6'-hexabromobiphenyl (SS)	
octachloronaphthalene (QS)[2]	
d_{10}-phenanthrene (QS)	
d_{12}-chrysene (QS)	

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[1] Surrogate standard.

[2] Quantitation standard.

TABLE 7-3. ANALYTICAL CONDITIONS FOR TOX ANALYSIS

Hall Detector Conditions

Reactor temperature - 850°C
Solvent - n-propanol
Hydrogen flow rate - 35 mL/min

GC Conditions (Varian 3700)

Injection volume (1 - 5 uL)
Helium carrier gas flow rate - 60 mL/min
Column - 3-ft packed column with 1 in 10% OV-101
Column temperature - 200°C isothermal

placed in the Parr Bomb with 10 mL of a 50 g/L Na_2CO_3 solution. After combustion of the samples according to standard procedures (ASTM 2015), the contents of the bomb were rinsed into a 100 mL flask and diluted to 100 mL. The resulting solution was analyzed for chloride concentration (Cl^-) by IC using standard anion conditions. For samples difficult to combust (such as sludges), 25 drops of paraffin oils were added to the bomb prior to combustion.

8.0 QUALITY ASSURANCE/ QUALITY CONTROL (QA/QC)

This section summarizes results of the quality assurance and quality control (QA/QC) activities for field sampling and laboratory analyses for Site BLB-C. The flue gas and ESP ash dioxin/furan data for Site BLB-C were within the QC specifications presented in the Tier 4 QAPP. Surrogate recoveries for all the samples were within the specified limits of 50 to 120 percent for labeled TCDD's and 40 to 120 percent for hepta- and octa-CDD's. The results of the analysis of the fortified laboratory QC sample were within 25 percent of the true values for all homologues except for hepta-CDD/CDF. The measured values for the hepta homologues were within 50 percent of the measured values.

The dioxin/furan precursor analysis of the feed samples was not as accurate as the dioxin/furan homologue analysis. Surrogate recoveries of the base neutrals fraction were generally within the specified QC limits of 50 ± 100 percent; however, the surrogate acid fraction recoveries were well below the limits. This was due to difficulties with the clean up and extraction of the feed samples. In spite of the low recoveries of the acid fractions, the dioxin/furan precursor results are considered a reasonable approximation of the true precursor concentration in the feed samples.

The following sections summarize the results of all Site BLB-C QA/QC activities. Manual gas sampling methods are considered in Section 8.1 and continuous monitoring and molecular weight determinations are considered in Section 8.2. The laboratory analyses QA/QC are summarized in Section 8.3.

8.1 MANUAL GAS SAMPLING

Manual gas sampling methods at Site BLB-C included Modified Method 5 (MM5), HCl, EPA Methods 1 through 4, and ambient air/XAD sampling. These methods are discussed in Section 6.0. Quality assurance and quality control (QA/QC) activities for the manual sampling methods centered around (1) equipment calibration, (2) glassware pre-cleaning, (3) procedural QC checks and (4) sample custody procedures. Key activities and QC results in each of these areas are discussed in this section. Also discussed are problems encountered that may have affected data quality.

8.1.1 Equipment Calibration and Glassware Preparation

Pre-test calibrations or inspections were conducted on pitot tubes, sampling nozzles, temperature sensors and analytical balances. Both pre-test and post-test calibrations were performed on the dry gas meters. All of the field test equipment met the calibration criteria specified in the Tier 4 Quality Assurance Project Plan (QAPP). Differences in the pre-test and post-test dry gas meter calibrations were less than 2 percent (5).

A pre-cleaning procedure was used for all sample train glassware and sample containers. This cleaning procedure, which is outlined in Table 8-1, was implemented to minimize the potential for sample contamination with substances that could interfere with the dioxin/furan analysis. To minimize the potential for contamination in the field, all sample train glassware was capped with foil prior to use and stored in a dust controlled environment. Sample train assembly and recovery were performed in the on-site laboratory trailer.

8.1.2 Procedural QC Activities/Manual Gas Sampling

Procedural QC activities for dioxin/furan, HCl and ambient air sampling focused on:

- Visual equipment inspections,
- Preparation of sample train blanks,
- Ensuring the proper location and number of traverse points (dioxin/furan and HCl sampling)
- Conducting pre-test and post-test sample train leak checks,
- Maintaining proper temperature at the filter housing, sorbent trap and impinger train
- Maintaining isokinetic sampling rates (dioxin/furan and HCl sampling)
- Recording all data on preformatted field data sheets.

Site-specific observations related to these areas are discussed below.

The electrostatic precipitator inlet and outlet sampling locations at Site BLB-C were not ideal for traverse sampling because of traverse point access limitations. Details of the sampling locations were discussed in Section 6.1.1. At the inlet location, the first 10 traverse points at each of the two sample ports on the east half of the inlet duct were sampled. The

TABLE 8-1. GLASSWARE PRECLEANING PROCEDURE

NOTE: USE DISPOSABLE GLOVES AND ADEQUATE VENTILATION

1. Soak all glassware in hot soapy water (alconox^R) 50°C or higher.
2. Distilled/deionized H_2O rinse (X3).[a]
3. Chromerge^R rinse if glass, otherwise skip to 5.
4. High purity liquid chromatography grade H_2O rinse (X3).
5. Acetone rinse (X3), (pesticide grade).
6. Methylene chloride rinse (X3), (pesticide grade).
7. Cap glassware with clean glass plugs or methylene chloride rinsed aluminum foils.

---

[a] (X3) = three times.

last two sample points at each port were not sampled because they could not be reached using a 10 ft sample probe. The 10 ft probe was considered the best compromise between probe length and probe linear breakage considerations for this test location.

At the outlet location, 22 of the 24 traverse points were sampled. Two traverse points at Ports C (Figure 6-3) could not be reached because of the limited clearance (4 ft) between Port C and the wall of the sampling enclosure.

Results of the isokinetic calculations for the MM5 and HCl sampling runs are shown in Table 8-2. The average isokinetic sampling rate was within the QA objective of 100 ± 10 percent for each run except for the second MM5 run at the precipitator outlet location (Run 08-MM5-PO-2), which was at 114.1 percent isokinetic. This minor deviation from the QA objective does not significantly affect the data quality for the test run. The average isokinetic sampling rate was back within the QA objective for the third MM5 run at the precipitator outlet location.

Initial, final and port change leak checks for the MM5 and HCl sample trains were acceptable for all of the test runs. None of the reported sample volumes required correction for sample train leakage. All leak check data are noted on the MM5 and HCl field data sheets.

8.1.3 Sample Custody

Sample custody procedures used during this program emphasized documentation of the samples collected and the use of chain-of-custody records for samples transported to the laboratory for analysis. Steps taken to identify and document samples collected included labeling each sample with a unique alphanumeric code and logging the sample in a master logbook. All samples shipped to Troika or returned to Radian-RTP were also logged on chain-of-custody records that were signed upon receipt at the laboratory. Each sample container lid was individually sealed to ensure that samples were not tampered with.

One or more of the samples from Site BLB-C were reported by Troika to have leaked during shipment to the laboratory. This resulted in sample labels from nine samples being partially removed, and sample labels from two samples

TABLE 8-2. SUMMARY OF ISOKINETIC RESULTS FOR MM5

	MM5/Dioxin Sampling				HCl Sampling	
Run	Precipitator Inlet % Isokinetic	Meets QC Objective	Precipitator Outlet % Isokinetic	Meets QC Objective[a]	Precipitator Inlet % Isokinetic	Meets QC Objective
01	105.4	Yes	109.6	Yes	105.9	Yes
02	105.5	Yes	114.1	No	101.6	Yes
03	109.2	Yes	105.7	Yes	102.3	Yes

being completely removed. Troika was able to determine the identity of all the samples except the two for which the labels were completely removed. By the process of elimination, the two unknown samples were determined to be the impinger rinse from the inlet MM5 train for Run 01 and the probe rinse from the outlet MM5 train for Run 01.

8.2 CONTINUOUS MONITORING/ MOLECULAR WEIGHT DETERMINATION

Flue gas parameters measured continuously at the electrostatic precipitator outlet location during the MM5 test runs included CO, CO_2, O_2, SO_2, total hydrocarbons (THC) and NO_x. The concentration of O_2, CO_2 and nitrogen (N_2) were also determined for integrated bag samples of the flue gas. Quality control results for these analyses are discussed in this section.

Drift check results for the continuously monitored flue gas parameters are summarized in Table 8-3. The QC target goal of ± 10% drift for any test run was achieved for each instrument. Data reduction was performed by assuming a linear drift of the instrument response over the test day based on drift checks at the beginning and end of the day. The largest calibration drifts were observed for the SO_2 analyzer and the smallest instrument drift was observed in the O_2 monitor.

The quality control standards for this program consisted of mid-range concentration standards that were intended for QC purposes and not for instrument calibration. The QC gases were analyzed immediately after calibration each day to provide data on day-to-day instrument variability. The acceptance criteria for the analysis of each QC standard was agreement within ± 10 percent of the running mean value.

During test Run 01, it was determined that the concentrations of SO_2, NO_x and THC were too low to be detected using the ranges initially selected for these instruments. One hour and fifty minutes into Run 01, the instrument ranges were lowered to get viable readings on the instruments. This change resulted in the loss of SO_2 data for Run 01, but the NO_x and THC data were reduced and reported. The gases initially selected for QC purposes were used to perform the calibrations of these instruments after the range changes were made. As a result, there are no QC data for SO_2, NO_x, and THC for this test site.

TABLE 8-3. SUMMARY OF DRIFT CHECK AND CONTROL STANDARD RESULTS

			Drift Check			QC Standard			
Test Date	Test Run	Parameter	Input Concentration	Instrument Drift, %[a]	Meets QC?[b]	Input Concentration	Output Concentration	Difference From Running Mean, %	QC?[c]
5/23/85	01	O_2	21.1% V	-0.55	Yes	9.3% V	9.40	--	Yes
5/24/85	02	O_2	21.1% V	0.27	Yes	9.3% V	9.51	0.10	Yes
5/25/85	03	O_2	21.1% V	0.24	Yes	9.3% V	9.53	0.21	Yes
5/23/85	01	CO	5580 ppmv	1.24	Yes	2006.0 ppmv	2220.0	--	Yes
5/24/85	02	CO	5580 ppmv	-3.87	Yes	2006.0 ppmv	2278.0	1.29	Yes
5/25/85	03	CO	5580 ppmv	-2.29	Yes	2006.0 ppmv	2328.4	2.33	Yes
5/23/85	01	CO_2	18.0% V	0.78	Yes	13.0%	13.21	--	Yes
5/24/85	02	CO_2	18.0% V	4.06	Yes	13.0%	12.85	-1.38	Yes
5/25/85	03	CO_2	18.0% V	0.39	Yes	13.0%	13.16	0.69	Yes
5/23/85	01	SO_2	--	d	d	239.0 ppmv	232.6	--	Yes
5/24/85	02	SO_2	239 ppmv	7.15	Yes	e	e	e	e
5/25/85	03	SO_2	239 ppmv	-1.45	Yes	e	e	e	e
5/23/85	01	NO_x	--	d	d	155 ppmv	165.9	--	Yes
5/24/85	02	NO_x	155 ppmv	1.08	Yes	e	e	e	e
5/25/85	03	NO_x	155 ppmv	-6.02	Yes	e	e	e	e
5/23/85	01	THC	90 ppmv	d	d	90.0 ppmv	92.85	--	Yes
5/24/85	02	THC	90 ppmv	2.02	Yes	e	e	e	e
5/25/85	03	THC	90 ppmv	3.77	Yes	e	e	e	e

[a] Instrument drift is defined as the percent difference between the instrument response to the input concentration at the beginning and end of the test run.

[b] QC criteria was instrument drift within ± 10 percent.

[c] QC criteria was output concentration within ± 10 percent of the running mean concentration for this test site.

[d] No data. Initial and final calibration gases differed because of change in instrument range during test run.

[e] No data. QC gas used for calibration of instrument.

Molecular weight was determined by analyzing integrated bag samples of flue gas for O_2, CO_2, and N_2. Quality control for this analysis involved duplicate analyses of calibration gases immediately before and after sample analysis. Analysis of the calibration gases was repeated until two consecutive analyses within ± 5 percent were obtained. This sample criteria of ± 5 percent applied to duplicate analyses required for sample quantification. These criteria were met for all molecular weight determinations.

8.3 LABORATORY ANALYSES

QA/QC activities were carried out for dioxin/furan, dioxin precursor, and total chloride analyses performed on Site BLB-C samples. The dioxin/furan analyses of MM5 train samples performed by Troika are considered in Section 8.3.1; the dioxin precursor analyses of black liquor boiler feed samples performed by Radian/RTP are considered in Section 8.3.2; and the total chloride analyses of HCl train samples and process samples are considered in Section 8.3.3.

8.3.1 Dioxin/Furan Analyses

Two individual topics related to the dioxin/furan analyses at Site BLB-C are discussed in this section. Analytical recoveries of labeled surrogate compounds spiked onto MM5 train samples are reported in Section 8.3.1.1. Sample blank data are reported in Section 8.3.1.2.

8.3.1.1 Surrogate Recoveries of the Test Samples

To meet QA objectives, the surrogate recoveries should be within 100 ± 50%. Table 8-4 presents the analytical recovery data reported by Troika for four isotopically labeled surrogate compounds spiked onto the samples requiring dioxin/furan analysis. MM5 train samples were spiked with all four of the surrogates. Average recovery for the MM5 train samples was 75 percent for the inlet and 74 percent for the outlet.

The ESP ash samples were spiked with two isotopically labeled surrogate compounds. The average recovery was 77 percent.

The black liquor feed samples were analyzed for dioxin/furan precursors and spiked with six isotopically labelled compounds. The analytical recovery

TABLE 8-4. SURROGATE RECOVERIES FOR SITE BLB-C DIOXIN AND FURAN ANALYSES

Sample	Surrogate Recoveries (%)			
	$^{37}Cl_4$ TCDD	$^{13}C_{12}$ TCDD	$^{37}Cl_4$ Hepta-CDD	$^{13}C_{12}$-OCDD
MM5 Samples				
Inlet:				
Run 01	100	94	69	56
Run 02	84	68	74	65
Run 03	84	66	74	66
Outlet:				
Run 01	96	96	42	59
Run 02	96	96	55	62
Run 03	100	92	48	42
ESP Ash Samples				
Run 01	96	NS	NS	54
Run 02	98	NS	NS	56
Run 03	94	NS	NS	62

NS = not spiked. For ash samples, only $^{37}Cl_4$ TCDD and $^{13}C_{12}$ OCDD are spiked for surrogate recovery.

efficiencies of these surrogate compounds are summarized in Table 8-5. The average recovery was 42 percent.

8.3.1.2 Sample Blanks

Table 8-6 summarizes the analytical results reported by Troika for internal laboratory blanks and laboratory fortified quality control (QC) samples. In general, the data showed good surrogate recoveries, with values ranging from 55 to 102 percent. Comparison of the measured and spiked values for the laboratory fortified QC samples showed agreement to within ±25 percent for all target species except the hepta-CDD and hepta-CDF isomers. The measured value for the hepta homologues were 50 percent higher than the spiked value. To meet QA objectives, the measured value should be within ± 50% of the spiked value.

The analytical results of the quality control field and laboratory MM5 train blanks are summarized in Table 8-7. Dioxin/furan homologues were not detected in the MM5 laboratory proof blank except for octa-CDD. The MM5 laboratory proof blank is a set of cleaned glassware that has never been used for a test run at Site BLB-C. The results indicate that the glassware did not contain background levels of dioxin/furans.

The inlet field blank did not contain any dioxin/furan homologues except for octa-CDD, and field recovery of the MM5 samples is considered adequate for the inlet. However, the outlet field blank contained significant quantities of dioxin/furan homologues except for 2378 TCDD, 2378 TCDF and penta-CDF. The ratio of the field blank value to the minimum test value was at least 60%. The very large quantities of hepta- and octa-CDD were significantly higher than the values detected in the test runs, which indicates that the outlet field blank may have been contaminated and may be invalid. The test run data reported in Section 5.4 were not blank-corrected.

8.3.2 Total Chloride Analysis

Total chloride analyses were performed by Radian/Austin on the HCl train samples. QA/QC activities included total chloride analysis of field recovery blank HCl train samples, total chloride analysis of an aliquot of the KOH solution used in the sample train impingers, and duplicate total chloride

TABLE 8-5. PERCENT SURROGATE RECOVERIES FOR SITE BLB-C FEED SAMPLES

Surrogate Compound	Percent Surrogate Recovery			
	Black Liquor Feed Samples			
	Run 1	Run 2	Run 3	Average
Base Neutrals Fraction				
d_4-dichlorobenzene	73	58	ND	44
bromobiphenyl	76	72	47	65
2', 5, 5' tetra bromobiphenyl	114	70	61	82
Acids Fraction				
d_6-phenol	10	9	16	12
d_4-2-chlorophenol	20	26	38	28
^{13}C-pentachlorophenol	ND	27	39	22

TABLE 8-6. ANALYTICAL RESULTS FOR TROIKA QUALITY CONTROL SAMPLES FOR SITE BLB-C

	Troika Flue Gas Quality Control Samples				
			Fortified Laboratory QC Sample		
Compound	Proof Blank MM5 Train	Troika Laboratory Blank	Measured Value	True Value[a]	Difference[b] (Percent)
	Amount Detected (Nanograms per Sample)				
Dioxins					
2378 TCDD	NR	ND (0.02)	0.4	0.4	0
Other TCDD	ND (0.1)	ND (0.03)	ND (0.03)	ND	0
Penta CDD	ND (0.1)	ND (0.2)	ND (0.05)	ND	0
Hexa CDD	ND (0.1)	ND (0.06)	1.4	1.6	-13
Hepta CDD	ND (0.2)	ND (0.2)	3.6	2.4	50
Octa CDD	0.3	0.2	3.1	3.2	-3
Furans					
2378 TCDF	NR	ND (0.02)	0.5	0.4	25
Other TCDF	ND (0.2)	ND (0.03)	ND (0.04)	ND	0
Penta CDF	ND (0.04)	ND (0.01)	0.8	0.8	0
Hexa CDF	ND (0.1)	ND (0.04)	1.2	1.6	-25
Hepta CDF	ND (0.05)	ND (0.02)	3.5	2.4	46
Octa CDF	ND (0.04)	ND (0.02)	3.0	3.2	-6
	Surrogate Recoveries (Percent)				
$^{37}Cl_4$-TCDD	82	102	100	NA	
$^{13}C_{12}$-TCDD	114	98	102	NA	
$^{37}Cl_4$-Hepta CDD	42	72	62	NA	
$^{13}C_{12}$-Octa CDD	84	88	55	NA	

---

[a] True values represent the amounts of each homologue spiked into the laboratory fortified QC samples.

[b] Value shown in parenthesis is the percentage difference between the measured and true value:

$$\% = \frac{\text{Measured Value - True Value}}{\text{True Value}} \times 100$$

ND = Not detected (detection limit indicated in parenthesis)
NR = Not reported by Troika
NA = Not applicable
TCDD = Tetra-chlorinated dibenzo-p-dioxin

TABLE 8-7. ANALYTICAL RESULTS OF QUALITY CONTROL MM5 BLANKS FOR SITE BLB-C

Compound	Inlet			Outlet			
	Field Blank Value	Minimum Test Run Value	Ratio %	Field Blank Value	Minimum Test Run Value	Ratio %	Radian Laboratory Proof Blank
	Amount detected (Nanograms per sample)						
Dioxins							
2378 TCDD	ND (0.05)	NR	-	ND (0.02)	ND (0.01)	0	NR
Other TCDD	ND (0.2)	1.1	0	0.4	0.55	73	ND (0.1)[b]
Penta CDD	ND (0.1)	1.4	0	0.2	ND (0.1)	200	ND (0.1)
Hexa CDD	ND (0.1)	3.3	0	1.2	0.3	400	ND (0.1)
Hepta CDD	ND (0.1)	2.4	0	25.7	0.5	5140	ND (0.1)
Octa CDD	0.6	2.1	29	109.3	1.2	9100	0.3
Furans							
2378 TCDF	ND (0.16)	NR	-	ND (0.1)	ND (0.01)	0	NR
Other TCDF	ND (0.2)	2.1	0	0.3	0.5	60	ND (0.2)[b]
Penta CDF	ND (0.2)	ND (1.3)	0	ND (0.2)	ND (0.2)	0	ND (0.04)
Hexa CDF	ND (0.1)	1.7	0	1.4	0.5	280	ND (0.1)
Hepta CDF	ND (0.2)	0.50	0	5.2	0.4	1300	ND (0.05)
Octa CDF	ND (0.2)	ND (0.3)	0	3.5	0.2	1750	ND (0.04)
	Surrogate Recoveries (Percent)						
$^{37}Cl_4$-TCDD	76	-	-	90	-	-	82
$^{13}C_{12}$-TCDD	92	-	-	92	-	-	114
$^{37}C_4$-Hepta CDD	43	-	-	72	-	-	42
$^{13}C_{12}$-Octa CDD	52	-	-	93	-	-	84

NR = not reported

[a] Ratio of the field blank value to the minimum test run value expressed as a percentage.

[b] These values represent all tetra-homologues.

analyses of all individual train components. The KOH blank contained 7 mg/liter of chlorides. The HCl train probe rinse/filter blank contained less than 1 mg/L of chlorides and the HCl train impinger rinses contained 8 mg/L which is equivalent to 4.3 mg of chloride in the sample blank. Therefore, the impinger rinse results were blank-corrected by subtracting 4.3 mg from the total milligrams of chloride in each test run sample.

APPENDIX A
FIELD SAMPLING DATA

APPENDIX A-1

MODIFIED METHOD 5 AND EPA METHODS 1-4 FIELD RESULTS

A-1.1

ELECTROSTATIC PRECIPITATOR OUTLET MM5 RESULTS

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```
                R A D I A N   S O U R C E   T E S T
                E P A   M E T H O D   2 - 5
                ( R A W   D A T A )
             PLANT               : SITE #08
             PLANT SITE          :
             SAMPLING LOCATION   : ESP OUTLET
             TEST #              : 08-MM5-PO-1
             DATE                : 4/23/85
             TEST PERIOD         :
1220-1330 1357-1417 1430-1450 1512-1622 1635-1725


          PARAMETER                             VALUE
          ---------                             -----

          Sampling time (min.)                   235
          Barometric Pressure (in.Hg)            30.02
          Sampling nozzle diameter (in.)         .304
          Meter Volume (cu.ft.)                  146.418
          Meter Pressure (in.H2O)                1.28
          Meter Temperature (F)                  66.8
          Stack dimension (sq.in.)               22167.13
          Stack Static Pressure (in.H2O)        -.42
          Stack Moisture Collected (gm)          740.1
          Absolute stack pressure(in Hg)         29.98912
          Average stack temperature (F)          292.4
          Percent CO2                            7.4
          Percent O2                             13.8
          Percent N2                             78.8
          Delps Subroutine result                13.33708
          DGM Factor                             1
          Pitot Constant                         .84
```

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```
                    R A D I A N   S O U R C E   T E S T
                    E P A   M E T H O D S   2 - 5
                    F I N A L   R E S U L T S
                  PLANT                  : SITE #08
                  PLANT SITE             :
                  SAMPLING LOCATION      : ESP OUTLET
                  TEST #                 : 08-MM5-PO-1
                  DATE                   : 4/23/85
                  TEST PERIOD            :
1220-1330 1357-1417 1430-1450 1512-1622 1635-1725


                    PARAMETER                      RESULT
                    ---------                      ------

                    Vm(dscf)                        147.7036
                    Vm(dscm)                        4.182967
                    Vw gas(scf)                     34.89572
                    Vw gas (scm)                    .9882466
                    % moisture                      19.11054
                    Md                              .8088946
                    MWd                             29.736
                    MW                              27.49319
                    Vs(fpm)                         2001.3
                    Vs (mpm)                        610.1524
                    Flow(acfm)                      308076.9
                    Flow(acmm)                      8724.738
                    Flow(dscfm)                     175282.4
                    Flow(dscmm)                     4963.998
                    % I                             109.5753
                    % EA                            197.0528




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```
         R A D I A N   S O U R C E   T E S T
         E P A   M E T H O D   2 - 5
         ( R A W   D A T A )
      PLANT                 : SITE #8
      PLANT SITE            :
      SAMPLING LOCATION     : ESP OUTLET
      TEST #                : 08-MM5-PO-2
      DATE                  : 4/24/85
      TEST PERIOD           :
1035-1125 1140-1240 1315-1345 1350-1420 1425-1555


    PARAMETER                              VALUE
    ---------                              -----

    Sampling time (min.)                    240
    Barometric Pressure (in.Hg)            30.25
    Sampling nozzle diameter (in.)          .304
    Meter Volume (cu.ft.)                  155.685
    Meter Pressure (in.H2O)                1.373333
    Meter Temperature (F)                  73.38
    Stack dimension (sq.in.)               22167.13
    Stack Static Pressure (in.H2O)        -.42
    Stack Moisture Collected (gm)          818.7
    Absolute stack pressure(in Hg)         30.21912
    Average stack temperature (F)          294.4792
    Percent CO2                            7.22
    Percent O2                             14.04
    Percent N2                             78.74
    Delps Subroutine result                13.34398
    DGM Factor                             .9993
    Pitot Constant                          .84
```

```
          R A D I A N   S O U R C E   T E S T
          E P A   M E T H O D S   2 - 5
          F I N A L   R E S U L T S
        PLANT                  : SITE #8
        PLANT SITE             :
        SAMPLING LOCATION      : ESP OUTLET
        TEST #                 : 08-MM5-PO-2
        DATE                   : 4/24/85
        TEST PERIOD            :
1035-1125 1140-1240 1315-1345 1350-1420 1425-1555


          PARAMETER                      RESULT
          ---------                      ------

          Vm(dscf)                        156.2252
          Vm(dscm)                        4.424297
          Vw gas(scf)                     38.60171
          Vw gas (scm)                    1.0932
          % moisture                      19.81334
          Md                              .8018666
          MWd                             29.7168
          MW                              27.39531
          Vs(fpm)                         1998.261
          Vs (mpm)                        609.2258
          Flow(acfm)                      307609.1
          Flow(acmm)                      8711.489
          Flow(dscfm)                     174344.5
          Flow(dscmm)                     4937.435
          % I                             114.0931
          % EA                            208.0814




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```
                R A D I A N   S O U R C E   T E S T
                E P A   M E T H O D   2 - 5
                ( R A W   D A T A )
              PLANT                  : SITE #8
              PLANT SITE             :
              SAMPLING LOCATION      : ESP OUTLET
              TEST #                 : 08-MM5-EO-3
              DATE                   : 4/25/85
              TEST PERIOD            :
0925-1035 1055-1155 1205-1235 1241-1311 1324-1414


            PARAMETER                                VALUE
            ---------                                -----

            Sampling time (min.)                      240
            Barometric Pressure (in.Hg)               30.29
            Sampling nozzle diameter (in.)            .304
            Meter Volume (cu.ft.)                     142.234
            Meter Pressure (in.H2O)                   1.07
            Meter Temperature (F)                     82.5
            Stack dimension (sq.in.)                  22167.13
            Stack Static Pressure (in.H2O)           -.42
            Stack Moisture Collected (gm)             730.5
            Absolute stack pressure(in Hg)            30.25912
            Average stack temperature (F)             296.9167
            Percent CO2                               6.98
            Percent O2                                13.58
            Percent N2                                79.44
            Delps Subroutine result                   12.95228
            DGM Factor                                .9993
            Pitot Constant                            .84
```

```
        R A D I A N   S O U R C E   T E S T
        E P A   M E T H O D S   2 - 5
        F I N A L   R E S U L T S
      PLANT                : SITE #8
      PLANT SITE           :
      SAMPLING LOCATION    : ESP OUTLET
      TEST #               : 08-MM5-EO-3
      DATE                 : 4/25/85
      TEST PERIOD          :
0925-1035 1055-1155 1205-1235 1241-1311 1324-1414

        PARAMETER                 RESULT
        ---------                 ------

        Vm(dscf)                   140.4099
        Vm(dscm)                   3.976408
        Vw gas(scf)                34.44308
        Vw gas (scm)               .9754279
        % moisture                 19.69831
        Md                         .8030169
        MWd                        29.66
        MW                         27.36318
        Vs(fpm)                    1939.459
        Vs (mpm)                   591.2984
        Flow(acfm)                 298557.2
        Flow(acmm)                 8455.139
        Flow(dscfm)                169134.7
        Flow(dscmm)                4789.895
        % I                        105.7016
        % EA                       183.7081



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A-1.2

ELECTROSTATIC PRECIPITATOR INLET MM5 RESULTS (EAST DUCT)

```
     R A D I A N   S O U R C E   T E S T
     E P A   M E T H O D   2 - 5
     ( R A W   D A T A )
   PLANT                 : SITE #8
   PLANT SITE            :
   SAMPLING LOCATION     : ESP INLET
   TEST #                : 08-MM5-EI-1
   DATE                  : 4/23/85
   TEST PERIOD           : 1222-1322 1355-1435 1440-1500 1515-1635

 PARAMETER                                  VALUE
 ---------                                  -----

 Sampling time (min.)                        200
 Barometric Pressure (in.Hg)                 30.04
 Sampling nozzle diameter (in.)              .311
 Meter Volume (cu.ft.)                       112.885
 Meter Pressure (in.H2O)                     1.203
 Meter Temperature (F)                       65.99
 Stack dimension (sq.in.)                    10800
 Stack Static Pressure (in.H2O)              .08
 Stack Moisture Collected (gm)               530.3
 Absolute stack pressure(in Hg)              30.04588
 Average stack temperature (F)               313.85
 Percent CO2                                 8.899999
 Percent O2                                  12.7
 Percent N2                                  78.4
 Delps Subroutine result                     12.18476
 DGM Factor                                  .9945
 Pitot Constant                              .84
```

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```
     R A D I A N   S O U R C E   T E S T
     E P A   M E T H O D S   2 - 5
     F I N A L   R E S U L T S
PLANT                :  SITE #8
PLANT SITE           :
SAMPLING LOCATION    :  ESP INLET
TEST #               :  08-MM5-EI-1
DATE                 :  4/23/85
TEST PERIOD          :  1222-1322 1355-1435 1440-1500 1515-1635

     PARAMETER                 RESULT
     ---------                 ------

     Vm(dscf)                   113.4783
     Vm(dscm)                   3.213705
     Vw gas(scf)                25.00365
     Vw gas (scm)               .7081032
     % moisture                 18.05553
     Md                         .8194447
     MWd                        29.932
     MW                         27.77762
     Vs(fpm)                    1817.284
     Vs (mpm)                   554.05
     Flow(acfm)                 136296.3
     Flow(acmm)                 3859.911
     Flow(dscfm)                76525.16
     Flow(dscmm)                2167.193
     % I                        105.4744
     % EA                       158.7977


                                      Program Revision:1/16/
```

```
           R A D I A N   S O U R C E   T E S T
           E P A   M E T H O D   2 - 5
           ( R A W   D A T A )
        PLANT                  : SITE #8
        PLANT SITE             :
        SAMPLING LOCATION      : ESP INLET
        TEST #                 : 08-MM5-EI-2
        DATE                   : 4/24/85
        TEST PERIOD            :
034-1059 1108-1138 1142-1227 1229-1309 1319-1409 1444-1454


      PARAMETER                                 VALUE
      ---------                                 -----

      Sampling time (min.)                       200
      Barometric Pressure (in.Hg)                30.27
      Sampling nozzle diameter (in.)             .311
      Meter Volume (cu.ft.)                      113.742
      Meter Pressure (in.H2O)                    1.21575
      Meter Temperature (F)                      73.4375
      Stack dimension (sq.in.)                   10800
      Stack Static Pressure (in.H2O)             .05
      Stack Moisture Collected (gm)              601.4
      Absolute stack pressure(in Hg)             30.27368
      Average stack temperature (F)              311.05
      Percent CO2                                8.7
      Percent O2                                 13.3
      Percent N2                                 78
      Delps Subroutine result                    12.33872
      DGM Factor                                 .9945
      Pitot Constant                             .84
```

```
          RADIAN SOURCE TEST
          EPA METHODS 2-5
          FINAL RESULTS
        PLANT                 : SITE #8
        PLANT SITE            :
        SAMPLING LOCATION     : ESP INLET
        TEST #                : 08-MM5-EI-2
        DATE                  : 4/24/85
        TEST PERIOD           :
34-1059 1108-1138 1142-1227 1229-1309 1319-1409 1444-1454

          PARAMETER                RESULT
          ---------                ------

          Vm(dscf)                  113.6076
          Vm(dscm)                  3.217368
          Vw gas(scf)               28.35601
          Vw gas (scm)              .8030423
          % moisture                19.97414
          Md                        .8002586
          MWd                       29.924
          MW                        27.54229
          Vs(fpm)                   1841.125
          Vs (mpm)                  561.3188
          Flow(acfm)                138084.4
          Flow(acmm)                3910.55
          Flow(dscfm)               76564.94
          Flow(dscmm)               2168.319
          % I                       105.5397
          % EA                      182.3917




                                       Program Revision:1/16/84
```

```
      R A D I A N   S O U R C E   T E S T
      E P A   M E T H O D   2 - 5
      ( R A W   D A T A )
    PLANT              : SITE #8
    PLANT SITE         :
    SAMPLING LOCATION  : ESP INLET
    TEST #             : 08-MM5-EI-3
    DATE               : 4/25/85
    TEST PERIOD        : 0941-1051 1103-1133 1137-1217 1226-1326

  PARAMETER                                VALUE
  ---------                                -----

  Sampling time (min.)                      200
  Barometric Pressure (in.Hg)               30.32
  Sampling nozzle diameter (in.)            .311
  Meter Volume (cu.ft.)                     108.293
  Meter Pressure (in.H2O)                   1.06
  Meter Temperature (F)                     65.6
  Stack dimension (sq.in.)                  10800
  Stack Static Pressure (in.H2O)            .05
  Stack Moisture Collected (gm)             577.3
  Absolute stack pressure(in Hg)            30.32368
  Average stack temperature (F)             308.65
  Percent CO2                               9
  Percent O2                                12.1
  Percent N2                                78.9
  Delps Subroutine result                   11.48137
  DGM Factor                                .9945
  Pitot Constant                            .84
```

```
   R A D I A N   S O U R C E   T E S T
   E P A   M E T H O D S   2 - 5
   F I N A L   R E S U L T S
PLANT                  : SITE #8
PLANT SITE             :
SAMPLING LOCATION      : ESP INLET
TEST #                 : 08-MM5-EI-3
DATE                   : 4/25/85
TEST PERIOD            : 0941-1051 1103-1133 1137-1217 1226-1326

   PARAMETER                   RESULT
   ---------                   ------

   Vm(dscf)                     109.9174
   Vm(dscm)                     3.11286
   Vw gas(scf)                  27.2197
   Vw gas (scm)                 .7708618
   % moisture                   19.84853
   Md                           .8015147
   MWd                          29.924
   MW                           27.55726
   Vs(fpm)                      1711.317
   Vs (mpm)                     521.7431
   Flow(acfm)                   128348.8
   Flow(acmm)                   3634.838
   Flow(dscfm)                  71619.09
   Flow(dscmm)                  2028.253
   % I                          109.1631
   % EA                         138.6089




                                          Program Revision:1/16/84
```

A-1.3

ELECTROSTATIC PRECIPITATOR INLET VELOCITY DETERMINATION RESULTS (WEST DUCT)

```
   R A D I A N   S O U R C E   T E S T
   E P A   M E T H O D . 2 - 5
   ( R A W   D A T A )
 PLANT                   : SITE #8
 PLANT SITE              :
 SAMPLING LOCATION       : ESP INLET
 TEST #                  : 08 VELOCITY 01
 DATE                    : 4/23/85
 TEST PERIOD             : AM

PARAMETER                                    VALUE
---------                                    -----

Sampling time (min.)
Barometric Pressure (in.Hg)                 30.04
Sampling nozzle diameter (in.)
Meter Volume (cu.ft.)
Meter Pressure (in.H2O)
Meter Temperature (F)
Stack dimension (sq.in.)                    10800
Stack Static Pressure (in.H2O)              .04
Stack Moisture Collected (gm)
Absolute stack pressure(in Hg)              30.04294
Average stack temperature (F)               317.7
Percent CO2                                 8.899999
Percent O2                                  12.7
Percent N2                                  78.4
Delps Subroutine result                     15.6325
DGM Factor
Pitot Constant                              .84
```

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```
         R A D I A N ,  S O U R C E   T E S T
         E P A   M E T H O D S   2 - 5
         F I N A L   R E S U L T S
PLANT                   : SITE #8
PLANT SITE              :
SAMPLING LOCATION       : ESP INLET
TEST #                  : 08 VELOCITY 01
DATE                    : 4/23/85
TEST PERIOD             : AM

         PARAMETER                RESULT
         ---------                ------

         Vm(dscf)
         Vm(dscm)
         Vw gas(scf)
         Vw gas (scm)
         % moisture                18.05553
         Md                        .8194447
         MWd                       29.932
         MW                        27.77762
         Vs(fpm)                   2331.608
         Vs (mpm)                  710.8561
         Flow(acfm)                174870.6
         Flow(acmm)                4952.335
         Flow(dscfm)               97687.53
         Flow(dscmm)               2766.511
         % I
         % EA




                                            Program Revision:1/16/
```

```
   RADIAN SOURCE TEST
   EPA METHOD 2-5
   (RAW DATA)
 PLANT                :  SITE #8
 PLANT SITE           :
 SAMPLING LOCATION    :  ESP INLET
 TEST #               :  08-VELOCITY-2
 DATE                 :  4/24/85
 TEST PERIOD          :  AM

PARAMETER                                  VALUE
---------                                  -----

Sampling time (min.)
Barometric Pressure (in.Hg)                 30.27
Sampling nozzle diameter (in.)
Meter Volume (cu.ft.)
Meter Pressure (in.H20)
Meter Temperature (F)
Stack dimension (sq.in.)                    10800
Stack Static Pressure (in.H20)              .13
Stack Moisture Collected (gm)
Absolute stack pressure(in Hg)              30.27956
Average stack temperature (F)               308.95
Percent CO2                                 8.7
Percent O2                                  13.3
Percent N2                                  78
Delps Subroutine result                     14.9021
DGM Factor
Pitot Constant                              .84
```

```
          R A D I A N   S O U R C E   T E S T
          E P A   M E T H O D S   2 - 5
          F I N A L   R E S U L T S
PLANT                 : SITE #8
PLANT SITE            :
SAMPLING LOCATION     : ESP INLET
TEST #                : 08-VELOCITY-2
DATE                  : 4/24/85
TEST PERIOD           : AM

     PARAMETER                    RESULT
     ---------                    ------

     Vm(dscf)
     Vm(dscm)
     Vw gas(scf)
     Vw gas (scm)
     % moisture                    19.97414
     Md                            .8002586
     MWd                           29.924
     MW                            27.54229
     Vs(fpm)                       2223.405
     Vs (mpm)                      677.8673
     Flow(acfm)                    166755.3
     Flow(acmm)                    4722.511
     Flow(dscfm)                   92732.91
     Flow(dscmm)                   2626.196
     % I
     % EA





                                        Program Revision:1/16/
```

RADIAN SOURCE TEST
EPA METHOD 2-5
(RAW DATA)

PLANT : SITE #8
PLANT SITE :
SAMPLING LOCATION : ESP INLET
TEST # : 08-VELOCITY-3
DATE : 4/25/85
TEST PERIOD : AM

PARAMETER	VALUE
Sampling time (min.)	
Barometric Pressure (in.Hg)	30.32
Sampling nozzle diameter (in.)	
Meter Volume (cu.ft.)	
Meter Pressure (in.H2O)	
Meter Temperature (F)	
Stack dimension (sq.in.)	10800
Stack Static Pressure (in.H2O)	-.16
Stack Moisture Collected (gm)	
Absolute stack pressure(in Hg)	30.30824
Average stack temperature (F)	300.65
Percent CO2	9
Percent O2	12.1
Percent N2	78.9
Delps Subroutine result	13.32505
DGM Factor	
Pitot Constant	.84

```
          R A D I A N   S O U R C E   T E S T
          E P A   M E T H O D S   2 - 5
          F I N A L   R E S U L T S
       PLANT                : SITE #8
       PLANT SITE           :
       SAMPLING LOCATION    : ESP INLET
       TEST #               : 08-VELOCITY-3
       DATE                 : 4/25/85
       TEST PERIOD          : AM

          PARAMETER                 RESULT
          ---------                 ------

          Vm(dscf)
          Vm(dscm)
          Vw gas(scf)
          Vw gas (scm)
          % moisture                 19.84853
          Md                         .8015147
          MWd                        29.924
          MW                         27.55726
          Vs(fpm)                    1986.627
          Vs (mpm)                   605.679
          Flow(acfm)                 148997.1
          Flow(acmm)                 4219.596
          Flow(dscfm)                83972.52
          Flow(dscmm)                2378.102
          % I
          % EA



                                                  Program Revision:1/16/84
```

APPENDIX A-2

CONTINUOUS EMISSION MONITORING RESULTS

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```
CEMS DATA - SITE 08 - TEST 1

**       FACTOR          **          NORMALIZED / CORRECTED DATA - WITH ACTUAL O2
**     FOR 3% O2         **
**   NORMALIZATION       **
**         OF            **
**   OTHER PROCESS       **        TIME       O2       CO      CO2      NOX      THC
**       GASES           **                  (%V)   (PPMV)     (%V)   (PPMV)   (PPMV)
**                       **
**    ==========         **     =======  =======  =======  =======  =======  =======

**      2.1765           **        1250     12.7    369.7     18.6      0.4      2.5
**      1.9080           **        1255     11.5    615.2     17.2      0.0     22.2
**      1.8970           **        1300     11.5    542.4     17.3      0.0     27.4
**      2.9119           **        1305     14.8    638.9     17.7      0.0     44.1
**      1.8949           **        1310     11.5    759.1     17.2      0.0     29.2
**      1.8994           **        1315     11.5    921.0     17.2      0.0     31.5
**      2.6548           **        1320     14.2   1320.5     17.4      0.0     45.0
**      1.9005           **        1325     11.5   1085.0     17.1      0.0     38.3
**      1.9049           **        1330     11.5   1183.7     17.2      0.0     37.3
**      2.1454           **        1335     12.6    969.9     16.2      0.0     38.7
**      2.2470           **        1340     12.9    915.9     18.9      0.0     41.6
**      1.8995           **        1345     11.5    787.2     17.1      0.0     32.0
**      1.9026           **        1350     11.5    600.6     16.8      0.4     29.1
**      2.6950           **        1355     14.3    650.9     17.6      0.0     37.6
**      1.9087           **        1400     11.5    839.7     17.1      0.0     22.7
**      1.9003           **        1405     11.5   1259.9     17.1      0.0     21.6
**      2.6322           **        1410     14.1   1024.7     17.2      0.0     34.7
**      1.9028           **        1415     11.5    254.0     17.1      0.0     28.9
**      1.9100           **        1420     11.5    180.7     17.2      0.0     19.9
**      2.5919           **        1425     14.0    332.0     17.2      0.0     23.4
**      1.9665           **        1430     11.8    490.9     17.4      0.0     17.0
**      1.9164           **        1435     11.6    267.1     17.1      0.4     23.2
**      1.9314           **        1440     11.6    226.5     17.1     28.2     73.6
**      2.7432           **        1445     14.4    518.1     17.8     34.1     98.2
**      1.9612           **        1450     11.8    720.0     17.1     40.3     73.2
**      1.9328           **        1455     11.6    609.2     17.0     41.0     77.1
**      2.7335           **        1500     14.4    569.6     17.4     40.6    103.1
**      1.9483           **        1505     11.7    728.1     17.0     39.5     69.0
**      1.9664           **        1510     11.8    839.0     17.0     32.2     66.4
**      2.7043           **        1515     14.3    728.8     17.2     26.3     87.7
**      1.9830           **        1520     11.9    538.5     17.2     25.0     60.9
**      1.9599           **        1525     11.8    632.9     17.1     26.3     63.2
**      2.2994           **        1530     13.1    569.6     16.2     28.9     74.1
**      2.1096           **        1535     12.7    785.6     18.4     30.5     72.7
**      1.9422           **        1540     11.7    694.5     17.0     28.4     60.9
**      1.9338           **        1545     11.6    637.7     17.0     33.2     59.2
**      2.7310           **        1550     14.3    531.2     17.4     29.8     70.0
**      1.9556           **        1555     11.7    390.6     17.1     36.4     58.2
**      1.9380           **        1600     11.7    383.5     17.0     35.0     52.3
**      2.7224           **        1605     14.3    543.6     17.2     30.2     64.4
**      1.9250           **        1610     11.6    727.3     16.9     31.9     50.0
**      1.9064           **        1615     11.5    851.2     16.9     31.3     55.6
**      2.3777           **        1620     13.4    860.0     16.0     21.6     74.2
**      2.0392           **        1625     12.1    789.5     17.6     30.4     60.8
**      1.9150           **        1630     11.6    721.6     16.8     30.5     60.2
**      1.9514           **        1635     11.7    603.5     16.2     20.9     54.5
**      2.3627           **        1640     13.9    657.4     18.2     21.1     72.4
**      1.9180           **        1645     11.6    536.7     16.9     27.6     40.0
**      1.9197           **        1650     11.6    537.4     16.9     29.1     40.4
**      2.6751           **        1655     14.2    497.8     17.3     24.7     53.0
**      1.9477           **        1700     11.7    650.9     17.0     30.4     40.4
**      1.9232           **        1705     11.6    620.5     17.0     38.6     41.9
**      2.3610           **        1710     13.9    405.5     17.4     55.3     57.0
**      1.8610           **        1715     11.3    159.3     17.0     60.9     35.1
**      1.8619           **        1720     11.3    169.7     16.9     58.7     26.5
**      1.9233           **        1725     11.6    140.1     16.1     57.7     26.0
**      2.3829           **        1730     13.4    107.7     18.2     67.4     34.1
**      1.8507           **        1735     11.2     89.5     16.9     63.9     25.6
**      1.8486           **        1740     11.2    104.0     16.9     62.9     21.3
**      2.5730           **        1745     13.9    110.3     17.0     63.9     28.3
**      1.8400           **        1750     11.2    103.1     16.8     63.5     22.9
**      1.8304           **        1755     11.2    103.3     16.8     66.0     23.2
**      2.5570           **        1800     13.9     21.4     17.1     66.2     32.4
**      1.8396           **        1805     11.2     61.2     16.8     67.6     19.3
===========================================================================================

NO. PTS.            64                  NO. PTS.      64       64       64       64       64
MEAN            2.1382                  MEAN        12.3    560.6     17.1     26.3     46.3
STD. DEV.          0.3                  STD. DEV.    1.1    384.9      0.5     22.7     21.9
```

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```
CEMS DATA - SITE 08 - TEST 2

**     FACTOR         **              NORMALIZED / CORRECTED DATA - WITH ACTUAL O2
**     FOR 3% O2      **
**   NORMALIZATION    **
**         OF         **
**   OTHER PROCESS    **       TIME       O2       CO      CO2      SO2      NOX      THC
**       GASES        **                (%V)   (PPMV)     (%V)   (PPMV)   (PPMV)   (PPMV)
**                    **
**    ==========      **    =======  =======  =======  =======  =======  =======  =======

**      3.8486        **       1035     16.2   1675.4     19.7    160.4     43.5     21.7
**      1.8921        **       1040     11.4   1269.0     16.5    128.1     43.1     28.0
**      1.8804        **       1045     11.4    848.2     16.5    115.0     32.0     25.1
**      2.5817        **       1050     14.0   1101.1     16.7     96.1     38.1     18.6
**      1.8952        **       1055     11.5   1340.5     16.5     89.5     38.9     11.4
**      1.8810        **       1100     11.4   1201.6     16.4     79.0     38.5     11.9
**      2.0747        **       1105     12.3    896.9     15.3     59.3     37.2     14.0
**      2.2864        **       1110     13.1   1050.1     17.7     55.7     43.9     12.6
**      1.9039        **       1115     11.5    896.1     16.3     49.7     42.5      8.6
**      1.8979        **       1120     11.5   1214.0     16.3     39.9     42.2      7.5
**      2.6059        **       1125     14.0    954.6     16.0     30.7     42.0     14.0
**      1.8987        **       1130     11.4    980.5     16.4     39.7     42.4     10.4
**      1.8801        **       1135     11.4    655.7     16.4     49.5     42.0      9.6
**      2.6354        **       1140     14.1    424.5     16.0     40.0     44.4     13.5
**      1.9023        **       1145     11.5    281.5     16.5     50.3     50.1      8.5
**      1.8873        **       1150     11.4    313.5     16.5     47.3     49.0      6.9
**      2.3228        **       1155     13.2    330.1     15.5     30.0     45.0      8.5
**      2.0518        **       1200     12.2    425.1     17.4     50.4     47.6      7.7
**      1.9067        **       1205     11.5    390.4     16.5     51.1     49.0      6.2
**      1.8926        **       1210     11.4    470.9     16.5     51.7     47.0      5.0
**      2.6177        **       1215     14.1    624.0     16.9     42.7     45.2      8.0
**      1.8898        **       1220     11.4    594.6     16.5     60.2     45.4      6.1
**      1.8898        **       1225     11.4    559.1     16.5     67.3     45.1      7.1
**      2.6037        **       1230     14.0    580.3     16.0     50.6     43.3      8.9
**      1.8772        **       1235     11.4    555.9     16.4     66.6     47.3      5.2
**      1.8806        **       1240     11.4    597.0     16.3     72.2     47.9      5.6
**      2.5787        **       1245     14.0    620.0     16.4     54.6     46.0      8.2
**      1.8928        **       1250     11.4    726.5     16.4    109.3     45.0      5.6
**      1.8838        **       1255     11.4    720.7     16.3     88.5     47.0      6.5
**      1.9288        **       1300     11.6    567.6     15.5     56.2     50.0      7.1
**      2.4792        **       1305     13.7    815.2     17.6     80.5     50.2      7.0
**      1.8947        **       1310     11.5    590.7     16.3     73.9     40.6      5.9
**      1.8770        **       1315     11.4    573.2     16.3     59.4     47.9      6.0
**      2.5912        **       1320     14.0    937.1     16.7     30.0     46.2      7.4
**      1.8766        **       1325     11.4   1041.7     16.3     70.0     44.0      5.6
**      1.8347        **       1330     11.1   1010.0     16.2     65.4     41.0      7.0
**      2.5277        **       1335     13.8   1390.0     16.3     57.5     38.3     10.4
**      1.8334        **       1340     11.1   1113.0     16.1     87.3     40.9      8.0
**      1.8341        **       1345     11.1   1241.9     16.1     82.2     40.0      9.2
**      2.3702        **       1350     13.3   1226.3     15.5     65.6     37.9     11.0
**      1.9297        **       1355     11.6   1147.6     16.6     69.9     41.7      9.9
**      1.8506        **       1400     11.2   1124.0     16.1     60.6     41.6      9.2
**      1.8253        **       1405     11.1   1160.7     16.0     63.2     40.6      9.0
**      2.5401        **       1410     13.9   1149.7     16.4     42.7     40.0     13.1
**      1.8398        **       1415     11.2   1254.0     16.1     86.9     42.4      8.5
**      1.8400        **       1420     11.2   1124.7     16.1    100.5     42.0      8.0
**      2.5514        **       1425     13.9   1200.9     16.4     63.0     39.4     12.5
**      1.8257        **       1430     11.1   1279.2     16.1     96.3     40.2      9.6
**      1.8222        **       1435     11.1   1127.0     16.2    101.5     41.7     11.4
**      2.4301        **       1440     13.5   1084.1     16.0     99.9     39.2     13.4
**      1.8732        **       1445     11.3   1224.0     16.6    130.5     41.1      9.5
**      1.8221        **       1450     11.1   1344.9     16.2    131.4     37.4      9.6
**      2.0400        **       1455     12.1   1125.7     15.1    123.1     36.0     11.3
**      2.1926        **       1500     12.7    589.4     17.7     84.6     49.4     14.2
**      1.8341        **       1505     11.1    441.5     16.4     57.4     49.0      7.4
**      1.8352        **       1510     11.1    765.9     16.5     31.5     41.0      3.0
**      2.5838        **       1515     14.0    980.7     16.0     60.0     37.3      7.4
**      1.8176        **       1520     11.1   1250.6     16.6     77.0     38.1      5.0
**      1.8077        **       1525     11.0   1376.4     16.7     40.9     39.7      8.4
**      2.5251        **       1530     13.8   1123.9     17.0      8.2     38.5     10.4
**      1.8338        **       1535     11.1    916.7     16.6     54.0     39.1     12.6
**      1.8253        **       1540     11.1   1033.1     16.7     63.0     40.0      8.9
**      2.0196        **       1545     12.0   1100.3     15.7      4.9     38.3      8.5
**      2.1873        **       1550     12.7   1262.9     18.3     12.6     41.6     13.5
**      1.8105        **       1555     11.0   1535.3     17.0     30.5     39.0     11.6
**      1.8311        **       1600     11.1   1538.6     17.0     21.6     41.4     10.0
**      2.5566        **       1605     13.9   1407.1     17.6     43.9     40.1     10.3
**      1.8454        **       1610     11.2   1337.4     17.0     47.0     42.0     12.0
**      1.8207        **       1615     11.1   1757.7     17.0     45.7     39.7     11.7
**      2.5421        **       1620     13.9   2106.3     17.3     20.9     38.0     19.2
**      1.8278        **       1625     11.1   2016.9     17.0     42.0     38.1     22.1
=========================================================================================

NO. PTS.        71                 NO. PTS.     71       71       71       71       71       71
MEAN        2.0870                 MEAN       12.1    997.7     16.6     64.9     42.7     10.6
STD. DEV.      0.4                 STD. DEV.   1.2    396.0      0.7     30.1      3.9      4.0
```

```
CEMS DATA - SITE 00 - TEST 3

**      FACTOR              **
**      FOR 3% O2           **               NORMALIZED / CORRECTED DATA - WITH ACTUAL O2
**      NORMALIZATION       **
**          OF              **
**      OTHER PROCESS       **          TIME       O2       CO      CO2      SO2      NOX      THC
**          GASES           **                   (%V)   (PPMV)     (%V)   (PPMV)   (PPMV)   (PPMV)
**                          **
**      ==========          **       =======  =======  =======  =======  =======  =======  =======

**        2.6289            **           925     14.1   1231.9     17.6     41.6     38.4     33.2
**        1.8723            **           930     11.3   1406.9     17.0     36.4     39.3     19.2
**        1.8684            **           935     11.3   1430.9     17.0     38.1     38.2     14.8
**        2.6755            **           940     14.1   1744.7     17.4     94.1     37.2     19.0
**        1.8833            **           945     11.4   1337.7     17.0     81.0     38.8     13.6
**        1.8986            **           950     11.4   1230.1     17.3     49.0     39.5     13.1
**        2.3190            **           955     13.2   1102.4     16.0     23.0     36.2     14.1
**        2.0529            **          1000     12.2   1345.7     18.1     23.5     39.6     12.5
**        1.8771            **          1005     11.4   1300.6     16.9      4.8     38.8     12.3
**        1.8673            **          1010     11.3   1450.4     17.0      7.5     37.2     14.0
**        2.6582            **          1015     14.2   1230.6     17.6     20.0     37.0     24.0
**        1.8700            **          1020     11.4   1205.0     17.0     53.7     30.1     16.1
**        1.8724            **          1025     11.3   1233.1     17.0     51.3     37.9     14.6
**        2.6020            **          1030     14.0   1216.7     17.4     63.0     37.1     30.4
**        1.8824            **          1035     11.4   1011.6     17.0     90.0     38.5     15.1
**        1.9019            **          1040     11.5    920.4     17.1     82.4     39.9     13.2
**        2.6353            **          1045     14.1   1044.9     17.3     94.6     39.5     11.7
**        1.9110            **          1050     11.5    912.1     17.1    117.9     41.5      6.9
**        1.9036            **          1055     11.5    947.9     17.0     82.3     40.9      6.9
**        1.9605            **          1100     11.8   1044.2     16.2     72.8     37.5      8.4
**        2.4662            **          1105     13.6   1189.7     18.6     64.2     37.9     12.4
**        1.8795            **          1110     11.4   1152.3     17.1     54.7     36.0     11.0
**        1.8800            **          1115     11.4   1246.7     17.0     35.7     36.9     12.5
**        2.6300            **          1120     14.1   1064.3     17.5     20.5     34.4     19.4
**        1.8996            **          1125     11.5    923.3     17.1     36.5     37.6     13.4
**        1.9009            **          1130     11.5   1007.2     17.1     35.0     37.0     11.6
**        2.6185            **          1135     14.1   1092.2     17.5     26.9     34.8     15.0
**        1.9042            **          1140     11.5    885.4     17.2     70.3     38.0     11.1
**        1.8900            **          1145     11.5    999.5     17.1     84.3     36.7      9.0
**        2.5286            **          1150     13.8    989.3     16.9     66.5     34.8     12.5
**        1.9351            **          1155     11.7   1451.4     17.4     67.0     37.0     10.4
**        1.8927            **          1200     11.4   1437.0     17.0     70.9     39.1     10.4
**        1.9041            **          1205     11.5   1620.0     17.0     94.1     38.5     15.1
**        2.6675            **          1210     14.2   1469.7     17.5    129.7     34.7     23.0
**        1.8899            **          1215     11.4   1731.1     17.0    135.7     36.9     15.9
**        1.8856            **          1220     11.4   1581.4     17.0     89.9     34.4     17.4
**        2.6010            **          1225     14.0   1611.6     17.4     76.1     35.5     20.2
**        1.8801            **          1230     11.4   1472.6     17.1    113.1     36.0     21.1
**        1.8740            **          1235     11.4   1670.6     17.0    126.6     38.4     16.5
**        2.4836            **          1240     13.7   1460.5     16.9    160.0     35.5     21.7
**        1.9546            **          1245     11.7   1579.6     17.4    190.6     37.7     17.0
**        1.8803            **          1250     11.4   1110.5     17.0    203.3     39.1     14.0
**        2.0869            **          1255     12.3   1092.9     16.0    166.7     36.6     15.4
**        2.3013            **          1300     13.1    767.9     18.7    159.9     42.3     12.0
**        1.8730            **          1305     11.4    625.0     17.1    138.9     39.0      8.1
**        1.8866            **          1310     11.4    269.2     17.1    171.4     47.0      6.4
**        2.5892            **          1315     14.0    425.4     17.7    157.4     48.1      7.2
**        1.8585            **          1320     11.3    290.2     17.3    143.5     49.0      4.2
**        1.8556            **          1325     11.3    300.0     17.0    110.6     46.6      3.7
**        2.6201            **          1330     14.1    432.2     17.6    142.1     44.0      4.7
**        1.8617            **          1335     11.3    515.9     17.1    170.5     46.1      4.0
**        1.8507            **          1340     11.2    533.3     17.0    130.3     46.6      4.2
**        2.1181            **          1345     12.4    400.0     16.0    126.5     44.4      5.0
**        2.2321            **          1350     12.9    637.0     18.7    154.2     40.0      6.4
**        1.8950            **          1355     11.5    701.2     17.1    202.7     43.5      5.3
**        1.8812            **          1400     11.4    635.6     17.2    172.0     40.9      5.9
**        2.5832            **          1405     14.0    831.0     18.1    102.3     42.2      8.1
**        1.8578            **          1410     11.3    725.2     17.1     84.7     41.9      6.0
**        1.8495            **          1415     11.2    599.3     17.3     72.1     42.0      6.6
**        2.5922            **          1420     14.0    504.0     18.0     72.5     41.7     10.2
**        1.8375            **          1425     11.2    730.4     17.5    120.0     43.9      6.7
**        1.8300            **          1430     11.2    600.2     17.4     70.3     45.5      7.2
**        2.5250            **          1435     13.8    624.0     17.2     52.3     42.5      9.6
**        1.8665            **          1440     11.3    960.5     17.7    123.2     41.9      6.2
**        1.8540            **          1445     11.2    817.0     17.2    116.3     42.0      5.9
**        1.8679            **          1450     11.3    604.0     16.9    106.9     45.0      6.7
**        2.5031            **          1455     13.7    995.7     18.1    146.0     42.4      9.7
**        1.8461            **          1500     11.2    912.9     17.2    102.1     40.2      7.2
*************************************************************************************************

NO. PTS.        68                 NO. PTS.       68       68       68       68       68       68
MEAN        2.0960                 MEAN         12.2   1023.6     17.2     95.6     39.9     12.2
STD. DEV.      0.3                 STD. DEV.     1.1    371.0      0.5     51.1      3.7      6.0
```

APPENDIX A-3
HCl TRAIN RESULTS

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```
            R A D I A N   S O U R C E   T E S T
            E P A   M E T H O D   2 - 5
            ( R A W   D A T A )
        PLANT                  : SITE #8
        PLANT SITE             :
        SAMPLING LOCATION      : ESP OUTLET
        TEST #                 : 08-HCL-PO-1
        DATE                   : 4/23/85
        TEST PERIOD            : 1234-1435

     PARAMETER                                 VALUE
     ---------                                 -----

     Sampling time (min.)                       121
     Barometric Pressure (in.Hg)                30.02
     Sampling nozzle diameter (in.)             .308
     Meter Volume (cu.ft.)                      74.57
     Meter Pressure (in.H2O)                    1.175
     Meter Temperature (F)                      78.25
     Stack dimension (sq.in.)                   22167.13
     Stack Static Pressure (in.H2O)            -.42
     Stack Moisture Collected (gm)              365.1
     Absolute stack pressure(in Hg)             29.98912
     Average stack temperature (F)              295.4167
     Percent CO2                                7.4
     Percent O2                                 13.8
     Percent N2                                 78.8
     Delps Subroutine result                    13.03279
     DGM Factor                                 .9993
     Pitot Constant                             .84
```

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```
     R A D I A N   S O U R C E   T E S T
     E P A   M E T H O D S   2 - 5
     F I N A L   R E S U L T S
PLANT                  : SITE #8
PLANT SITE             :
SAMPLING LOCATION      : ESP OUTLET
TEST #                 : 08-HCL-PO-1
DATE                   : 4/23/85
TEST PERIOD            : 1234-1435

     PARAMETER                   RESULT
     ---------                   ------

     Vm(dscf)                     73.55413
     Vm(dscm)                     2.083053
     Vw gas(scf)                  17.21447
     Vw gas (scm)                 .4875137
     % moisture                   18.96522
     Md                           .8103478
     MWd                          29.736
     MW                           27.51024
     Vs(fpm)                      1955.034
     Vs (mpm)                     596.047
     Flow(acfm)                   300954.9
     Flow(acmm)                   8523.041
     Flow(dscfm)                  170852.9
     Flow(dscmm)                  4838.553
     % I                          105.9188
     % EA                         197.0528



                                          Program Revision:1/16/
```

RADIAN SOURCE TEST
EPA METHOD 2-5
(RAW DATA)

PLANT : SITE #8
PLANT SITE :
SAMPLING LOCATION : ESP OUTLET
TEST # : 08-HCL-PO-2
DATE : 4/24/85
TEST PERIOD : 1033-1233

PARAMETER	VALUE
Sampling time (min.)	120
Barometric Pressure (in.Hg)	30.25
Sampling nozzle diameter (in.)	.308
Meter Volume (cu.ft.)	66.044
Meter Pressure (in.H20)	1.141667
Meter Temperature (F)	78.16666
Stack dimension (sq.in.)	22167.13
Stack Static Pressure (in.H20)	-.42
Stack Moisture Collected (gm)	341.7
Absolute stack pressure(in Hg)	30.21912
Average stack temperature (F)	293.3
Percent CO2	7.22
Percent O2	14.04
Percent N2	78.7
Delps Subroutine result	12.16768
DGM Factor	.9933
Pitot Constant	.84

```
     R A D I A N   S O U R C E   T E S T
     E P A   M E T H O D S   2 - 5
     F I N A L   R E S U L T S
PLANT                  : SITE #8
PLANT SITE             :
SAMPLING LOCATION      : ESP OUTLET
TEST #                 : 08-HCL-PO-2
DATE                   : 4/24/85
TEST PERIOD            : 1033-1233

     PARAMETER                    RESULT
     ---------                    ------

     Vm(dscf)                      65.25267
     Vm(dscm)                      1.847956
     Vw gas(scf)                   16.11116
     Vw gas (scm)                  .456268
     % moisture                    19.80138
     Md                            .8019862
     MWd                           29.7056
     MW                            27.38773
     Vs(fpm)                       1822.362
     Vs (mpm)                      555.5983
     Flow(acfm)                    280531.6
     Flow(acmm)                    7944.654
     Flow(dscfm)                   159270.3
     Flow(dscmm)                   4510.535
     % I                           101.6379
     % EA                          208.4076



                                                 Program Revision:1/16/
```

RADIAN SOURCE TEST
EPA METHOD 2-5
(RAW DATA)

PLANT : SITE #8
PLANT SITE :
SAMPLING LOCATION : ESP OUTLET
TEST # : 08-HCL-EO-3
DATE : 4/25/85
TEST PERIOD : 0957-1157

PARAMETER	VALUE
Sampling time (min.)	120
Barometric Pressure (in.Hg)	30.29
Sampling nozzle diameter (in.)	.308
Meter Volume (cu.ft.)	65.302
Meter Pressure (in.H2O)	1.12
Meter Temperature (F)	88.03
Stack dimension (sq.in.)	22167.13
Stack Static Pressure (in.H2O)	-.42
Stack Moisture Collected (gm)	334
Absolute stack pressure(in Hg)	30.25912
Average stack temperature (F)	301.5
Percent CO2	6.98
Percent O2	13.58
Percent N2	79.44
Delps Subroutine result	12.02712
DGM Factor	1.0086
Pitot Constant	.84

```
   R A D I A N   S O U R C E   T E S T
   E P A   M E T H O D S   2 - 5
   F I N A L   R E S U L T S
PLANT                : SITE #8
PLANT SITE           :
SAMPLING LOCATION    : ESP OUTLET
TEST #               : 08-HCL-EO-3
DATE                 : 4/25/85
TEST PERIOD          : 0957-1157

   PARAMETER                    RESULT
   ---------                    ------

   Vm(dscf)                      64.41573
   Vm(dscm)                      1.824253
   Vw gas(scf)                   15.7481
   Vw gas (scm)                  .4459862
   % moisture                    19.6449
   Md                            .803551
   MWd                           29.66
   MW                            27.36941
   Vs(fpm)                       1800.722
   Vs (mpm)                      549.0006
   Flow(acfm)                    277200.3
   Flow(acmm)                    7850.311
   Flow(dscfm)                   156194.5
   Flow(dscmm)                   4423.429
   % I                           102.3101
   % EA                          183.7081



                                        Program Revision:1/16/
```

APPENDIX A-4

MODIFIED METHOD 5 AND EPA METHODS 1-4 SAMPLE CALCULATIONS

RADIAN SOURCE TEST
EPA METHODS 2-5
DEFINITION OF TERMS

PARAMETER	DEFINITION
Tt(min.)	TOTAL SAMPLING TIME
Dn(in.)	SAMPLING NOZZLE DIAMETER
Ps(in.H2O)	ABSOLUTE STACK STATIC GAS PRESSURE
Vm(cu.ft.)	ABSOLUTE VOLUME OF GAS SAMPLE MEASURED BY DGM
Vw(gm.)	TOTAL STACK MOISTURE COLLECTED
Pm(in.H2O)	AVERAGE STATIC PRESSURE OF DGM
Tm(F)	AVERAGE TEMPERATURE OF DGM
Pb(in.Hg.)	BAROMETRIC PRESSURE
% CO2	CARBON DIOXIDE CONTENT OF STACK GAS
% O2	OXYGEN CONTENT OF STACK GAS
% N2	NITROGEN CONTENT OF STACK GAS
SQR(DELPS)	AVE. SQ. ROOT OF S-PITOT DIFF. PRESSURE-TEMP. PRODUCTS
As(sq.in.)	CROSS-SECTIONAL AREA OF STACK(DUCT)
Ts(F)	TEMPERATURE OF STACK
Vm(dscf)	STANDARD VOLUME OF GAS SAMPLED ,Vm(std),AS DRY STD. CF
Vm(dscm)	STANDARD VOLUME OF GAS SAMPLED,Vm(std),AS DRY STD. CM
Vw gas(scf)	VOLUME OF WATER VAPOR IN GAS SAMPLE,STD
% moisture	WATER VAPOR COMPOSITION OF STACK GAS
Md	PROPORTION, BY VOLUME,OF DRY GAS IN GAS SAMPLE
MWd	MOLECULAR WEIGHT OF STACK GAS,DRY BASIS LB/LB-MOLE
MW	MOLECULAR WEIGHT OF STACK GAS,WET BASIC LB/LB-MOLE
Vs(fpm)	AVERAGE STACK GAS VELOCITY
Flow(acfm)	AVERAGE STACK GAS FLOW RATE(ACTUAL STACK COND.)
Flow(acmm)	AVERAGE STACK GAS FLOW RATE(ACTUAL STACK COND.)
Flow(dscfm)	AVERAGE STACK GAS VOLUMETRIC FLOW RATE(DRY BASIS)
Flow(dscmm)	AVERAGE STACK GAS VOLUMETRIC FLOW RATE(DRY BASIS)
% I	PERCENT ISOKINETIC
% EA	PERCENT EXCESS AIR IN STACK GAS
DGM	DRY GAS METER
Y	DRY GAS METER CORRECTION FACTOR
Pg	STACK STATIC GAS PRESSURE
Cp	PITOT COEFFICIENT
dH	ORIFICE PLATE DIFF. PRESS. VALUE
dP	PITOT DIFF. PRESS. VALUE
*** EPA STANDARD CONDITIONS	Temperature = 68 deg-F (528 deg-R) Pressure = 29.92 in. Hg.

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```
                    RADIAN   SOURCE   TEST
                    EPA   METHOD   2 - 5
                    SAMPLE   CALCULATION
                PLANT                  : SITE #08
                PLANT SITE             :
                SAMPLING LOCATION      : ESP OUTLET
                TEST #                 : 08-MM5-PO-1
                DATE                   : 4/23/85
                TEST PERIOD            :
1220-1330 1357-1417 1430-1450 1512-1622 1635-1725

1) Volume of dry gas sampled at standard conditions (68 deg-F ,29.92 in. Hg).

                 Y x Vm x [T(std) + 460] x [Pb +(Pm/13.6)]
      Vm(std) = ---------------------------------------
                      P(std) x (Tm + 460)

                 1 x 146.418  x 528 x [ 30.02  + ( 1.28 /13.6)]
      Vm(std) = ------------------------------------------
                     29.92    x ( 66.8  + 460)

      Vm(std) =  147.704dscf

2) Volume of water vapor at standard conditions:

      Vw(gas) =  0.04715 cf/gm x W(l) gm

      Vw(gas) =  0.04715 x  740.1    =  34.896 scf

3) Percent Moisture in stack gas :

                 100 x Vw(gas)
      %M = --------------------
             Vm(std)   + Vw(gas)

                 100 x  34.896
      %M = -------------------- =  19.11 %
            147.704 +   34.896

4) Mole fraction of dry stack gas :

      Md   =     100 -    %M           100 -  19.11
                -----------       = ------------ =  .8088946
                    100                  100
```

SAMPLE CALCULATION
PAGE TWO

5)Average Molecular Weight of DRY stack gas :

```
        MWd = (.44 x %CO2) + (.32 x %O2) + (.28 x %N2)

        MWd = (.44 x 7.4 ) + (.32 x 13.8 ) + (.28 x  78.8 ) =  29.736
```

6)Average Molecular Weight of wet stack gas :

```
        MW   = MWd x Md + 18(1 - Md)

        MW   = 29.736  x  .8088946  + 18(1 -  .8088946 )  =  27.49319
```

7) Stack gas velocity in feet-per-minute (fpm) at stack conditions :

```
Vs = KpxCp x [SQRT (dP)]$ave↑ x SQRT [Ts $avg↑] x SQRT [1/(PsxMW)] x 60sec/min
   Vs = 85.49 x .84 x 60 x  13.33708 x SQRT[1/( 29.98912  X  27.49319 )]
   Vs =  2001.3  FPM
```

8) Average stack gas dry volumetric flow rate (DSCFM) :

```
           Vs x As x Md x T(std) x Ps
  Qsd =  ---------------------------------------
         144 cu.in./cu.ft. x (Ts +460) x P(std)

          2001.3 x 22167.13 x .8088946 x528x 29.98912
  Qsd =  ---------------------------------------
          144 x  752.4  x 29.92

  Qsd =  175282.4 dscfm
```

```
                    S A M P L E   C A L C U L A T I O N
                    P A G E   T H R E E

9)Isokinetic sampling rate (%) :

        Dimensional Constant C = K4 x 60 x 144 x [1 / (Pi  /4)]
        K4 = .0945 FOR ENGLISH UNITS

                  C x Vm(std) x (Ts + 460)
        I% =     ------------------------------------
                 Vs x Tt x Ps x Md x (Dn)*2

                  1039.574 x 147.7036 x 752.4
        I% = -------------------------------------------
                 2001.3 x 235 x 29.98912 x .8088946 x( .304 )*2

        I% =  109.5753

10) Excess air (%) :

                  100 x %O2              100 x 13.8
        EA =     --------------- = ---------------
                 (.264 x %N2) - %O2  (.264 x 78.8 ) - 13.8

        EA =        197.05

11) Particulate Concentration :

        Cs = ( grams part.) / Vm(std) =  0 / 147.7036

        Cs =        0.0000000 Grams/DSCF

                  T(std) x Md x Ps x Cs
        Ca =     ------------------------------
                  P(std) x Ts

                  528 x .8088946  x 29.98912  x       0.0000000
        Ca =     ------------------------------
                  29.92       x      752.4

        Ca =             0.0000000 Grams/ACF

        LBS/HR =  Cs x 0.002205 x Qsd x 60

        LBS/HR =         0.0000000x 0.002205 x175282.4 x 60

        LBS/HR = 0

                                                   Program Revision:1/16/84
```

APPENDIX B
PROCESS MONITORING DATA

APPENDIX B-1
BOILER BLB-C OPERATING LOG SHEETS

Reproduced from
best available copy.

30-146-88

#4 RECOVERY DAILY REPORT

TIME	12	2	4	6	8	10	12	2	4	6	8	10
Black Liq. Flow	273	272	273	273	[illegible]	[illegible]	[illegible]	[illegible]	222	223	[illegible]	[illegible]
Black Liq. Solids	62.1	62.2	61.8	62	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	63.7	[illegible]	[illegible]
Blk. Liq. Dens. PMT	643	643	642	642	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	63.3	[illegible]	[illegible]
Blk. Liq. Dens. SCMT	641	642	640	640	[illegible]	[illegible]	[illegible]	[illegible]	63.3	63.0	[illegible]	[illegible]
Nozzle Press.	24.	24	246	244	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Prim. Liq. Temp.	227	227	226	227	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	226	[illegible]	[illegible]
Sec. Liq. Temp.	224	224	224	225	[illegible]	[illegible]	[illegible]	[illegible]	223	224	[illegible]	[illegible]
Green Liq. Flow	581	601	687	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
W/W Flow	221	226	200	252	[illegible]	[illegible]	236	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
BE° East G.L. Diss.	[illegible]		[illegible]	23	24^5	23	24	23	22	24	23	
BE° West G.L. Diss.	[illegible]	[illegible]	21	24	23^5	24	26	23^5	24	22	23	
G.L. Total #4	[illegible]	[illegible]	[illegible]	71	71	6.7	7.4	6.8	71	75	71	
G.L. Total (Comp.)	[illegible]		7.3	70	6.1	7.0	6.7	6.1	70	[illegible]	[illegible]	
W/W Flow E. Scrubber	49	55	60	49	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
W/W Flow W. Scrubber	54	54	51	55	55	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
Total Air	319	[illegible]	311	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Prim. Air	159	147	139	138	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Prim. Duct Press.	19	17	17	15	[illegible]	[illegible]		[illegible]	[illegible]			[illegible]
Sec. Duct Press.	21	21	21	21	[illegible]	[illegible]		[illegible]	[illegible]		[illegible]	[illegible]
S.H. Draft	12	9	10	10	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Boiler Out	18	1.1	22	24	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Temp. E. Precip. IN	329	[illegible]	335	338	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
Temp. W. Precip. IN	335	334	313	318	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Air To E. LAH	91	94	75	75	[illegible]	[illegible]	[illegible]	[illegible]	72	[illegible]	[illegible]	[illegible]
Air From E. LAH	1.2	1.3	1.5	1.5	1.3	[illegible]		[illegible]	1.3	1.1	[illegible]	1.1
Air To W. LAH	75	72	75	72	[illegible]	[illegible]		[illegible]	70	71	[illegible]	[illegible]
Air From W. LAH	1.2	1.3	1.5	1.1	1.3	[illegible]	[illegible]	.5	.8	.5	[illegible]	[illegible]
Gas To E. LAH	1.6	1.6	1.7	2.0	1.7	[illegible]		1.2	1.3	[illegible]	[illegible]	[illegible]
Gas From E. LAH	4.6	[illegible]	4.9	5.1	4.7	[illegible]	[illegible]	[illegible]	3.6	[illegible]	[illegible]	[illegible]
Gas To W. LAH	1.5	1.6	1.4	1.7	1.6	.9	[illegible]	1.7	1.4	[illegible]	[illegible]	[illegible]
Gas From W. LAH	4.5	[illegible]	4.9	5.2	4.7	4.9		[illegible]	3.7	3.8	[illegible]	[illegible]
I.D. Fan Out	.9	.8	.7	.8	.7	.7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Boiler Press.	439	434	437	434	431	423	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Steam Flow	349	348	324	[illegible]	320	[illegible]	[illegible]	[illegible]	254	[illegible]	[illegible]	[illegible]
Inst. Air Press.	71	70	72	72	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
% Oxygen	3.3	3.4	3.5	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
% Combustibles	.03	.06	[illegible]	.04	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Smoke Density	2.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		1.6	[illegible]	[illegible]	[illegible]
TRS/o - ·3	.7	6	.7	.7								
Salt Cake # Min.	off											
Salt Cake Scale Wt.	lbs											

Salt @ 7:00 a.m. Tk.
@ 11:00 p.m. 12249316

Salt @ 3:00 p.m. at 455810
@ 7:00 a.m. 436596

Salt @ 11:00 p.m. a/ 2166
@ 3:00 p.m. 1676

Water: 12:00 M - 8:00 a.m.: 610
8:00 a.m. - 4:00 p.m.: 52
4:00 p.m. - 12:00 p.m.: 39

SR. Operators
12:00 - 8:00 Porter
8:00 - 4:00
4:00 - 12:00 Cook

Date [illegible] 23 [illegible]

Figure B.1 Boiler BLB-C Operating Log Sheet, Run 01

30-146-88

#4 RECOVERY DAILY REPORT

TIME	12	2	4	6	8	10	12	2	4	6	8	10
Black Liq. Flow	221	221	[illegible]	221	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Black Liq. Solids	[illegible]	63.3	[illegible]	63.9	[illegible]		[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
Blk. Liq. Dens. PMT	63.6	63.8	64	63.1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Blk. Liq. Dens. SCMT	63.3	63.6	63.7	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Nozzle Press.	20	20	20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	20	[illegible]	[illegible]	[illegible]
Prim. Liq. Temp.	226	226	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Sec. Liq. Temp.	224	224	[illegible]	224	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	223	[illegible]	[illegible]
Green Liq. Flow	578	472	[illegible]	[illegible]	[illegible]				[illegible]	[illegible]		
W/W Flow	219	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6E	[illegible]	—	—	—	—
BE° East G.L. Diss.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	24	25	24.5	15	5	24	[illegible]
BE° West G.L. Diss.	[illegible]	[illegible]	[illegible]	[illegible]	23	22	[illegible]	25	24	22	22.5	[illegible]
G.L. Total #4	[illegible]	[illegible]		[illegible]	9.2	67	[illegible]	9.2	76	71	[illegible]	[illegible]
G.L. Total (Comp.)	[illegible]	[illegible]		[illegible]	9.9	71	1.7	6.8	[illegible]	72	[illegible]	71
W/W Flow E. Scrubber	51	57	51	54	[illegible]	[illegible]	[illegible]	34	[illegible]	[illegible]	[illegible]	[illegible]
W/W Flow W. Scrubber	55	55	54	[illegible]	[illegible]	50	[illegible]	[illegible]	54	55	[illegible]	[illegible]
Total Air	243	225	[illegible]	220	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Prim. Air	120	118	118	117	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	112	[illegible]	[illegible]
Prim. Duct Press.	.5	.7	[illegible]	.7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Sec. Duct Press.	.6	.1	.3	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
S.H. Draft	1.0	1.0	[illegible]	1.6	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
Boiler Out	1.7	1.8	1.7	1.6	[illegible]		[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
Temp. E. Precip. IN	315	212	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Temp. W. Precip. IN	317	[illegible]	[illegible]	226	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Air To E. LAH	91	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Air From E. LAH	.9	[illegible]	.7	.7	.9	[illegible]	[illegible]	[illegible]	.7	[illegible]	[illegible]	[illegible]
Air To W. LAH	71	66	[illegible]	75	[illegible]	70	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Air From W. LAH	.8	.7	.8	.7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Gas To E. LAH	1.4	1.3	1.3	1.3	1.3	1.5	1.4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Gas From E. LAH	3.4	[illegible]	3.5	3.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Gas To W. LAH	1.6	1.2	1.4	1.3	1.3	1.3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Gas From W. LAH	3.4	3.2	3.4	3.4	[illegible]	3.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
I.D. Fan Out	.8	.7	.7	.7	[illegible]	.7	.7	[illegible]	.7	[illegible]	[illegible]	[illegible]
Boiler Press.	418	436	442	418	[illegible]	425	425		422	[illegible]	420	[illegible]
Steam Flow	300	302	281	364	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
Inst. Air Press.	74	65	58	71	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
% Oxygen	3.1	1.8	[illegible]	2.2	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
% Combustibles	0	0	.2	.1	[illegible]	[illegible]	[illegible]		.2	[illegible]	[illegible]	[illegible]
Smoke Density	1.1	1.1	[illegible]	1.3	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
TRS .3 - 3.	1.7	[illegible]	2	2.4								
Salt Cake # Min.	100									[illegible]		
Salt Cake Scale Wt.	OFF									[illegible]		

Salt @ 7:00 a.m. [illegible]

@ 11:00 p.m. 12756239

Salt @ 3:00 p.m. #4 464 106

@ 7:00 a.m. #55 810

Salt @ 11:00 p.m. [illegible] 317.3

@ 3:00 p.m. 316.6

Date 4-24-85

Water: 12:00 M - 8:00 a.m.: 261

8:00 a.m. - 4:00 p.m.: [illegible]

4:00 p.m. - 12:00 p.m.: [illegible]

BARTON R 3.6 7:20

SR. Operators

12:00 - 8:00 Philes

8:00 - 4:00 [illegible]

4:00 - 12:00 [illegible]

Figure B.2 Boiler BLB-C Operating Log Sheet, Run 02

30-146-88

PMT : Density meter #1 } on line
SCMT : Density meter #2 }
Black Liq Solid: Via microwave drying

#4 RECOVERY DAILY REPORT

TIME	12	2	4	6	8	10	12	2	4	6	8	10
	1556	1385	1385	1208	[illegible]	1428	1428	[illegible]	[illegible]	[illegible]	1950	[illegible]
Black Liq. Flow GPM	214	190	191	220	199	197	197	197	193	[illegible]	[illegible]	[illegible]
Black Liq. Solids	62.9	61.4	64.5	61.9	61.9	[illegible]	63.5	65.2	63.4	64.1	61.9	[illegible]
Blk. Liq. Dens. PMT	65.5	65.5	65.5	65.4	[illegible]	66.2	66.5	66.5	[illegible]	66.3	65.0	[illegible]
Blk. Liq. Dens. SCMT	65.4	65.4	65.3	65.4	[illegible]	66.1	66.2	66.2	[illegible]	66.1	65.0	64.9
Nozzle Press.	19	20	21	20	22	22.5	22.5	22	22	24.5	[illegible]	[illegible]
Prim. Liq. Temp.	226	226	225	225	227	227	227	227	[illegible]	227	[illegible]	[illegible]
Sec. Liq. Temp.	224	224	222	222	[illegible]	225	225	225	[illegible]	[illegible]	[illegible]	[illegible]
Green Liq. Flow	—	—	—	—	—	—	—	611	[illegible]	[illegible]	[illegible]	[illegible]
W/W Flow	—	—	—	—	—	—	—	221	[illegible]	[illegible]	[illegible]	[illegible]
BE° East G.L. Diss.	[illegible]	27	[illegible]	22	25	25	23.5	22	23	25	23	23
BE° West G.L. Diss.	22	23	[illegible]	22	22.5	23	24	26	24.5	23	25	24
G.L. Total #4	74	73	73	67	7.1	7.3	7.1	7.1	7.0	7.4	7.1	[illegible]
G.L. Total (Comp.)	70	74	73	69	6.9	7.4	7.3	7.3	7.1	7.2	7.1	[illegible]
W/W Flow E. Scrubber	55	54	54	54	[illegible]	54	59	54	[illegible]	[illegible]	[illegible]	59
W/W Flow W. Scrubber	55	54	55	55	[illegible]	55	55	55	54	55	[illegible]	55
Total Air	229	228	247	231	[illegible]	231	223	221	[illegible]	[illegible]	[illegible]	[illegible]
Prim. Air	114	122	121	121	[illegible]	[illegible]	105	104	111	[illegible]	[illegible]	[illegible]
Prim. Duct Press.	.4	.8	.7	.6	[illegible]	5	5	5	[illegible]	5	[illegible]	[illegible]
Sec. Duct Press.	.3	.2	1.0	1.6	[illegible]	6	4	7	[illegible]	[illegible]	[illegible]	[illegible]
S.H. Draft	.9	.9	1.1	1.0	[illegible]	.9	1.2	9	.7	[illegible]	.7	.9
Boiler Out	1.6	1.5	2.0	1.6	[illegible]	1.5	1.9	1.6	1.5	[illegible]	[illegible]	1.7
Temp. E. Precip. IN	326	309	304	314	[illegible]	311	309	309	[illegible]	[illegible]	[illegible]	[illegible]
Temp. W. Precip. IN	334	318	313	319	[illegible]	317	312	311	[illegible]	[illegible]	[illegible]	[illegible]
Air To E. LAH	87	87	79	79	[illegible]	79	86	93	[illegible]	[illegible]	[illegible]	[illegible]
Air From E. LAH	.8	.8	.8	1.8	[illegible]	.8	.7	.7	.8	1.0	[illegible]	[illegible]
Air To W. LAH	70	69	66	62	[illegible]	66	70	77	77	77	[illegible]	71
Air From W. LAH	.8	.7	.9	0	[illegible]	.7	.6	.6	.7	1.1	1.1	1.0
Gas To E. LAH	1.4	1.2	1.6	2.9	1.2	1.1	1.2	1.3	[illegible]	1.6	[illegible]	1.4
Gas From E. LAH	3.2	3.0	3.5	8.0	2.8	2.7	3.0	3.1	[illegible]	4.1	4.5	4.1
Gas To W. LAH	1.3	1.1	1.5	.9	1.3	1.3	1.3	1.2	1.2	1.7	[illegible]	[illegible]
Gas From W. LAH	3.4	3.0	3.5	8.2	[illegible]	3.0	3.0	2.9	[illegible]	4.1	4.4	[illegible]
I.D. Fan Out	.6	.6	.7	.5	[illegible]	.7	.8	6	[illegible]	[illegible]	[illegible]	7
Boiler Press.	420	419	430	428	[illegible]	418	420	422	[illegible]	[illegible]	[illegible]	[illegible]
Steam Flow	302	316	348	322	[illegible]	292	305	328	[illegible]	[illegible]	[illegible]	[illegible]
Inst. Air Press.	85	85	84	87	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
% Oxygen	1.8	1.8	2.3	3.0	[illegible]	2.2	2.3	1.7	[illegible]	[illegible]	[illegible]	[illegible]
% Combustibles	0	.1	0	0	[illegible]	0	0	0	[illegible]	[illegible]	[illegible]	[illegible]
Smoke Density	1.0	1.1	1.2	2.4	[illegible]	.4	.4	.4	[illegible]	[illegible]	[illegible]	[illegible]
TRS	.6	.6	.8	.4								
Micro Salt ~~Salt cake~~ ~~[illegible]~~ Pump	1.83	[illegible] →		1.7	→				[illegible]			
Salt Cake Scale Wt. Level	1543			[illegible]					14"			

[illegible] Oil on 1st Isolate Burner [illegible] F1458 / 300 [illegible]

Salt @ 7:00 a.m. [illegible]
@ 11:00 p.m. 1376 1378

Salt @ 3:00 p.m. #4 473249
@ 7:00 a.m. 464106

Salt @ 11:00 p.m. [illegible] 245.6
@ 3:00 p.m. 217.3

Water: 12:00 M - 8:00 a.m.: 911
8:00 a.m. - 4:00 p.m.: [illegible]
4:00 p.m. - 12:00 p.m.: [illegible]

1385# (190) @ 12:30
1000# (220) @ 6:00
1950 270 gpm 35%

SR. Operators
12:00 - 8:00 [illegible]
8:00 - 4:00 [illegible]
4:00 - 12:00 [illegible]

Date 4-25-85

Figure B.3 Boiler BLB-C Operating Log Sheet, Run 03

APPENDIX B-2
ELECTROSTATIC PRECIPITATOR OPERATING LOG SHEETS

Preceding page blank

D-146-77 PRECIP. REPORT #4 RECOVERY DATE [illegible]

	12	2	4	6	8	10	12	2	4	6	8	10
E & W OUTLET												
W. LOAD VOLTS	0	0	0	0								
E. LOAD VOLTS	0	0	0	0								
PRIM. VOLTS	0	0	0	0								
W. LOAD AMPS	0	0	0	0								
E. LOAD AMPS	0	0	0	0								
PRIM. AMPS	0	0	0	0								
E & W INLET												
W. LOAD VOLTS	58	58	57	58	57	58	60	57	58	60	60	[illegible]
E. LOAD VOLTS	57	58	57	58	57	58	60	57	58	60	60	[illegible]
PRIM. VOLTS	260	260	250	250	[illegible]	270	[illegible]	[illegible]	250	270	260	[illegible]
W. LOAD AMPS	25	24	22	21	[illegible]	28	[illegible]	[illegible]	26	28	[illegible]	[illegible]
E. LOAD AMPS	27	26	24	24	26	28	[illegible]	[illegible]	26	28	[illegible]	[illegible]
PRIM. AMPS	120	100	90	95	100	120	[illegible]	[illegible]	160	[illegible]	[illegible]	[illegible]
W. MIDDLE FIELD												
LOAD VOLTS	57	56	58	58	[illegible]	54	56	[illegible]	56	56	56	[illegible]
PRIM. VOLTS	[illegible]	310	315	310	[illegible]	[illegible]	[illegible]	[illegible]	310	310	310	[illegible]
LOAD AMPS	.85	.85	.85	.85	.85	.85	.85	.85	.85	.85	.85	[illegible]
PRIM. AMPS	[illegible]	160	160	160	[illegible]	160	[illegible]	[illegible]	160	160	165	[illegible]
W. OUTLET												
LOAD VOLTS	53	53	52	53	52	53	55	[illegible]	54	54	54	54
PRIM. VOLTS	330	330	330	330	[illegible]	[illegible]	[illegible]	[illegible]	340	340	340	[illegible]
LOAD AMPS	[illegible]	1.15	1.15	1.15	[illegible]	1.15	[illegible]	1.15	1.15	1.15	1.15	
PRIM. AMPS	200	200	200	200	[illegible]	[illegible]	[illegible]	200	200	[illegible]	[illegible]	
E. MIDDLE FIELD												
LOAD VOLTS	50	49	50	50	[illegible]	[illegible]	[illegible]	[illegible]	48	48	[illegible]	[illegible]
PRIM. VOLTS	290	290	285	285	[illegible]	[illegible]	[illegible]	[illegible]	280	280	[illegible]	[illegible]
LOAD AMPS	.65	.65	.65	.60	[illegible]	[illegible]	.75	[illegible]	.70	.65	[illegible]	[illegible]
PRIM. AMPS	125	130	130	130	[illegible]	[illegible]	155	[illegible]	130	125	[illegible]	[illegible]
E. OUTLET												
LOAD VOLTS	53	53	53	53	52	52	53	53	54	54	54	[illegible]
PRIM. VOLTS	300	300	290	295	300	290	[illegible]	300	300	[illegible]	[illegible]	
LOAD AMPS	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	[illegible]	[illegible]
PRIM. AMPS	215	215	210	215	215	215	215	215	[illegible]	215	[illegible]	[illegible]

SR. HELPERS: 12-8 Phillips 8-4 Cowlin 4-12 [illegible]

Figure B.4 Electrostatic Precipitator Operating Log Sheet, Run 01

10-146-77

PRECIP. REPORT #4 RECOVERY

DATE 4-24-85

	12	2	4	6	8	10	12	2	4	6	8	10
E & W OUTLET												
W. LOAD VOLTS												
E. LOAD VOLTS												
PRIM. VOLTS												
W. LOAD AMPS												
E. LOAD AMPS												
PRIM. AMPS												
E & W INLET												
W. LOAD VOLTS	60	58	[illegible]	58	57	60	58	57	60	58	58	58
E. LOAD VOLTS	60	58	[illegible]	58	[illegible]	[illegible]	[illegible]	[illegible]	60	58	58	58
PRIM. VOLTS	280	270	[illegible]	270	[illegible]	[illegible]	[illegible]	[illegible]	290	280	270	280
W. LOAD AMPS	32	30	[illegible]	30	[illegible]	[illegible]	[illegible]	[illegible]	.34	.36	.34	34
E. LOAD AMPS	32	30	[illegible]	30	[illegible]	[illegible]	[illegible]	[illegible]	.34	.36	.34	34
PRIM. AMPS	130	125	[illegible]	135	[illegible]	[illegible]	[illegible]	[illegible]	130	140	140	140
W. MIDDLE FIELD												
LOAD VOLTS	54	54	[illegible]	53	[illegible]	[illegible]	[illegible]	[illegible]	52	52	52	52
PRIM. VOLTS	300	300	[illegible]	285	[illegible]	[illegible]	[illegible]	[illegible]	300	290	290	290
LOAD AMPS	[illegible]	85	[illegible]	85	[illegible]	[illegible]	.75	[illegible]	85	85	.85	85
PRIM. AMPS	[illegible]	160	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	160	160	160	160
W. OUTLET												
LOAD VOLTS	55	[illegible]	53	53	[illegible]	[illegible]	[illegible]	[illegible]	54	54	54	54
PRIM. VOLTS	345	345	[illegible]	335	[illegible]	[illegible]	[illegible]	[illegible]	340	330	340	330
LOAD AMPS	1.15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	1.15	1.15	1.15	1.15
PRIM. AMPS	200	200	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	200	200	200	[illegible]
E. MIDDLE FIELD												
LOAD VOLTS	[illegible]	[illegible]	[illegible]	48	[illegible]		[illegible]	[illegible]	50	48	48	[illegible]
PRIM. VOLTS	[illegible]	[illegible]	[illegible]	290	[illegible]	[illegible]	[illegible]	[illegible]	300	300	300	[illegible]
LOAD AMPS	[illegible]	75	[illegible]	85	[illegible]	[illegible]	[illegible]	[illegible]	.95	.90	.90	90
PRIM. AMPS	[illegible]	145	[illegible]	150		[illegible]	[illegible]	[illegible]	175	155	160	[illegible]
E. OUTLET												
LOAD VOLTS	[illegible]	[illegible]	[illegible]	[illegible]	52	54	53	52	52	52	52	52
PRIM. VOLTS	[illegible]	290	285	[illegible]	[illegible]	[illegible]	300	[illegible]	290	300	300	290
LOAD AMPS	1.15	1.15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.15	1.15	1.15	1.15	1.15
PRIM. AMPS	215	212	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	215	215	215	[illegible]

SR. HELPERS: 12-8 ____ 8-4 Cawlin ____ 4-12 ____

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Figure B.5 Electrostatic Precipitator Operating Log Sheet, Run 02

-146-77

PRECIP. REPORT #4 RECOVERY

DATE 4/25/75

	12	2	4	6	8	10	12	2	4	6	8	10
E & W OUTLET												
W. LOAD VOLTS					[illegible]	48	42	[illegible]	48	44	46	46
E. LOAD VOLTS						[illegible]	43	[illegible]	250	240	240	44
PRIM. VOLTS						250	250	255	48	240	240	240
W. LOAD AMPS						46	[illegible]	47	.46	.46	.48	.48
E. LOAD AMPS						50	50	50	.50	.50	.50	.50
PRIM. AMPS						215	[illegible]	[illegible]	210	220	220	215
E & W INLET												
W. LOAD VOLTS	58	58	60	56	60	58	52	52	58	58	58	58
E. LOAD VOLTS	58	58	60	56	54	52	52	[illegible]	58	58	58	58
PRIM. VOLTS	280	270	280	250	250	260	[illegible]	[illegible]	270	250	270	260
W. LOAD AMPS	36	28	28	24	32	31	.30	[illegible]	.30	.20	.26	.28
E. LOAD AMPS	36	30	30	26	34	.38	.32	[illegible]	.30	.24	30	.28
PRIM. AMPS	140	130	125	100	120	160	[illegible]	[illegible]	120	100	110	110
W. MIDDLE FIELD												
LOAD VOLTS	52	54	54	56	54	54	54	[illegible]	54	58	56	56
PRIM. VOLTS	280	300	300	315	310	[illegible]	[illegible]	[illegible]	300	330	320	310
LOAD AMPS	75	85	85	85	.85	[illegible]	[illegible]	[illegible]	.85	.85	.85	85
PRIM. AMPS	160	160	160	160	160	[illegible]	[illegible]	[illegible]	165	160	160	160
W. OUTLET												
LOAD VOLTS	54	54	56	54	54	54	[illegible]	[illegible]	54	53	54	54
PRIM. VOLTS	340	340	345	340	350	340	[illegible]	[illegible]	350	340	330	330
LOAD AMPS	1.15	1.15	1.15	1.15	1.15	1.15	[illegible]	[illegible]	1.15	1.16	1.16	1.15
PRIM. AMPS	200	200	200	200	200	200	200	[illegible]	200	200	200	200
E. MIDDLE FIELD												
LOAD VOLTS	42	46	46	45	[illegible]	[illegible]	[illegible]	[illegible]	46	48	48	50
PRIM. VOLTS	275	290	290	275	[illegible]	[illegible]	[illegible]	[illegible]	280	280	290	295
LOAD AMPS	70	75	80	60	.70	[illegible]	[illegible]	[illegible]	.75	.60	.65	.70
PRIM. AMPS	[illegible]	140	150	110	[illegible]	[illegible]	[illegible]	[illegible]	165	130	130	125
E. OUTLET												
LOAD VOLTS	52	52	54	54	54	54	53	53	52	54	54	52
PRIM. VOLTS	315	280	300	315	300	295	[illegible]	[illegible]	300	300	300	300
LOAD AMPS	1.15	1.15	1.15	1.10	1.15	1.15	[illegible]	[illegible]	1.15	1.15	1.15	1.15
PRIM. AMPS	215	215	215	205	215	215	[illegible]	[illegible]	215	210	210	215

SR. HELPERS: 12-8 [illegible] 8-4 [illegible] 4-12 WATKIN

Figure B.6 Electrostatic Precipitator Operating Log Sheet, Run 03

Table B-1. Mean Electrostatic Precipitator Operating Data During Test Periods

	Run 01	Run 02	Run 03
E & W Outlet			
W. Load Voltage (kV)	Not Operating	Not Operating	48
E. Load Voltage (kV)	Not Operating	Not Operating	48
Prim. Volts (V)	Not Operating	Not Operating	250
W. Load Amps (A)	Not Operating	Not Operating	0.47
E. Load Amps (A)	Not Operating	Not Operating	0.50
Prim. Amps (A)	Not Operating	Not Operating	214
E & W Inlet			
W. Load Voltage (kV)	59	59	58
E. Load Voltage (kV)	59	59	58
Prim. Volts (V)	268	280	273
W. Load Amps (A)	0.28	0.33	0.31
E. Load Amps (A)	0.28	0.33	0.32
Prim. Amps (A)	110	128	120
W. Middle Field			
Load Voltage (kV)	56	53	55
Prim. Volts (V)	310	300	304
Load Amps (A)	0.85	0.85	0.85
Prim. Amps (A)	160	160	161
W. Outlet			
Load Voltage (kV)	54	54	54
Prim. Volts (V)	340	340	344
Load Amps (A)	1.15	1.15	1.15
Prim. Amps (A)	200	200	200
E. Middle Field			
Load Voltage (kV)	48	48	48
Prim. Volts (V)	283	290	280
Load Amps (A)	0.71	0.80	0.78
Prim. Amps (A)	135	150	148
E. Outlet			
Load Voltage (kV)	54	53	53
Prim. Volts (V)	300	298	298
Load Amps (A)	1.15	1.15	1.15
Prim. Amps (A)	2.15	2.15	2.15

APPENDIX C
LABORATORY ANALYTICAL DATA

TABLE C-1. DIOXIN/FURAN ANALYTICAL RESULTS FOR THE ESP OUTLET MM5 SAMPLES

ANALYTICAL DATA INPUT MATRIX FOR SITE BLB-C (OUTLET)
(picograms per sample train)

	RUN 01		RUN 02		RUN 03	
Species	Value	DL	Value	DL	Value	DL
2378 TCDD	.00	40.00	.00	20.00	.00	10.00
Other TCDD	200.00	.00	550.00	.00	250.00	.00
2378 TCDF	.00	60.00	80.00	.00	.00	10.00
Other TCDF	500.00	.00	1320.00	.00	1350.00	.00
Penta-CDD	.00	100.00	1100.00	.00	400.00	.00
Penta-CDF	.00	200.00	1100.00	.00	1900.00	.00
Hexa-CDD	300.00	.00	2100.00	.00	950.00	.00
Hexa-CDF	500.00	.00	1150.00	.00	2050.00	.00
Hepta-CDD	500.00	.00	6100.00	.00	1900.00	.00
Hepta-CDF	400.00	.00	1700.00	.00	1500.00	.00
Octa-CDD	1200.00	.00	12000.00	.00	1800.00	.00
Octa-CDF	200.00	.00	200.00	.00	200.00	.00

Value = amount detected in MM5 sample train.
DL = detection limit of GC/MS analysis.

TABLE C-2. DIOXIN/FURAN ANALYTICAL RESULTS FOR THE ESP INLET MM5 SAMPLES

ANALYTICAL DATA INPUT MATRIX FOR SITE BLB-C
(picograms per sample train)

	RUN 01		RUN 02		RUN 03	
Species	Value	DL	Value	DL	Value	DL
2378 TCDD	.00	.00	.00	.00	.00	.00
Other TCDD	2600.00	.00	1050.00	.00	1200.00	.00
2378 TCDF	.00	.00	.00	.00	.00	.00
Other TCDF	19800.00	.00	2050.00	.00	2200.00	.00
Penta-CDD	3300.00	.00	1550.00	.00	1400.00	.00
Penta-CDF	18900.00	.00	1200.00	.00	.00	1300.00
Hexa-CDD	5100.00	.00	3300.00	.00	3400.00	.00
Hexa-CDF	14000.00	.00	1650.00	.00	1600.00	.00
Hepta-CDD	4500.00	.00	2550.00	.00	2400.00	.00
Hepta-CDF	3700.00	.00	600.00	.00	500.00	.00
Octa-CDD	3000.00	.00	2100.00	.00	2100.00	.00
Octa-CDF	500.00	.00	300.00	.00	.00	300.00

Value = amount detected in MM5 sample train.
DL = detection limit of GC/MS analysis.

TABLE C-3. COMPOUND-SPECIFIC DIOXIN PRECURSOR DATA FOR SITE BLB-C FEED SAMPLES

Precursor Compounds	Precursor Concentration, ug/g (ppm)			
	Black Liquor Feed Samples			
	Run 1	Run 2	Run 3	Average
Base Neutrals Fraction				
Chlorinated Benzenes:				
Dichlorobenzenes	ND	ND	ND	
Trichlorobenzenes	ND	ND	ND	
Tetrachlorobenzenes	ND	ND	ND	
Pentachlorobenzenes	ND	ND	ND	
Hexachlorobenzenes	ND	ND	ND	
Total Chlorinated Benzenes	0	0	0	
Chlorinated Biphenyls:				
Chlorobiphenyls	ND	ND	ND	
Dichlorobiphenyls	ND	ND	ND	
Trichlorobiphenyls	ND	ND	ND	
Tetrachlorobiphenyls	ND	ND	ND	
Pentachlorobiphenyls	ND	ND	ND	
Hexachlorobiphenyls	ND	ND	ND	
Heptachlorobiphenyls	ND	ND	ND	
Octachlorobiphenyls	ND	ND	ND	
Nonachlorobiphenyls	ND	ND	ND	
Decachlorobiphenyls	ND	ND	ND	
Total Chlorinated Biphenyls	0	0	0	
Acids Fraction				
Chlorinated Phenols:				
Dichlorophenols	ND	ND	ND	
Trichlorophenols	ND	ND	ND	
Tetrachlorophenols	ND	ND	ND	
Pentachlorophenols	0	trace	0.01	
Total Chlorinated Phenols	0	trace	0.01	

APPENDIX D

RUN-SPECIFIC DIOXIN/FURAN EMISSIONS DATA

APPENDIX D-1

AS-MEASURED RUN-SPECIFIC DIOXIN/FURAN EMISSIONS DATA

TABLE D-1. SITE BLB-C DIOXIN/FURAN EMISSIONS DATA FOR RUN 1 AT THE ESP OUTLET (As-measured Concentrations)

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm)	Isomer Concentration In Flue Gas (ppt)	Isomer Hourly Emissions Rate (ug/hr)
DIOXINS			
2378 TCDD	ND (9.57E-03)	ND (7.15E-04)	ND (2.85E+00)
Other TCDD	4.78E-02(N/A)	3.57E-03(N/A)	1.43E+01
Penta-CDD	ND (2.39E-02)	ND (1.62E-03)	ND (7.13E+00)
Hexa-CDD	7.18E-02(N/A)	4.42E-03(N/A)	2.14E+01
Hepta-CDD	1.20E-01(N/A)	6.77E-03(N/A)	3.56E+01
Octa-CDD	2.87E-01(N/A)	1.50E-02(N/A)	8.55E+01
Total PCDD	5.26E-01	2.98E-02	1.57E+02
FURANS			
2378 TCDF	ND (1.44E-02)	ND (1.13E-03)	ND (4.28E+00)
Other TCDF	1.20E-01(N/A)	9.40E-03(N/A)	3.56E+01
Penta-CDF	ND (4.78E-02)	ND (3.39E-03)	ND (1.43E+01)
Hexa-CDF	1.20E-01(N/A)	7.67E-03(N/A)	3.56E+01
Hepta-CDF	9.57E-02(N/A)	5.63E-03(N/A)	2.85E+01
Octa-CDF	4.78E-02(N/A)	2.59E-03(N/A)	1.43E+01
Total PCDF	3.83E-01	2.53E-02	1.14E+02

NOTE: Isomer concentrations shown are at as-measured oxygen conditions.

ND = not detected (detection limit in parentheses).
N/A = detection limits not available. For positive samples the QA samples indicate the method capability and detection limits.
ng = 1.0E-09g
ug = 1.0E-06g
ppt = parts per trillion, dry volume basis
8760 operating hours per year

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TABLE D-2. SITE BLB-C DIOXIN/FURAN EMISSIONS DATA FOR RUN 2 AT THE ESP OUTLET (As-measured Concentrations)

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm)	Isomer Concentration In Flue Gas (ppt)	Isomer Hourly Emissions Rate (ug/hr)
DIOXINS			
2378 TCDD	ND (4.52E-03)	ND (3.38E-04)	ND (1.34E+00)
Other TCDD	1.24E-01(N/A)	9.30E-03(N/A)	3.69E+01
Penta-CDD	2.49E-01(N/A)	1.68E-02(N/A)	7.37E+01
Hexa-CDD	4.75E-01(N/A)	2.92E-02(N/A)	1.41E+02
Hepta-CDD	1.38E+00(N/A)	7.81E-02(N/A)	4.09E+02
Octa-CDD	2.71E+00(N/A)	1.42E-01(N/A)	8.04E+02
Total PCDD	4.94E+00	2.75E-01	1.46E+03
FURANS			
2378 TCDF	1.81E-02(N/A)	1.42E-03(N/A)	5.36E+00
Other TCDF	2.99E-01(N/A)	2.35E-02(N/A)	8.85E+01
Penta-CDF	2.49E-01(N/A)	1.76E-02(N/A)	7.37E+01
Hexa-CDF	2.60E-01(N/A)	1.67E-02(N/A)	7.71E+01
Hepta-CDF	3.85E-01(N/A)	2.26E-02(N/A)	1.14E+02
Octa-CDF	4.52E-02(N/A)	2.45E-03(N/A)	1.34E+01
Total PCDF	1.26E+00	8.43E-02	3.72E+02

NOTE: Isomer concentrations shown are at as-measured oxygen conditions.

ND = not detected (detection limit in parentheses).
N/A = detection limits not available. For positive samples the QA samples indicate the method capability and detection limits.
ng = 1.0E-09g
ug = 1.0E-06g
ppt = parts per trillion, dry volume basis
8760 operating hours per year

TABLE D-3. SITE BLB-C DIOXIN/FURAN EMISSIONS DATA FOR RUN 3 AT THE ESP OUTLET (As-measured Concentrations)

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm)	Isomer Concentration In Flue Gas (ppt)	Isomer Hourly Emissions Rate (ug/hr)
DIOXINS			
2378 TCDD	ND (2.51E-03)	ND (1.88E-04)	ND (7.22E-01)
Other TCDD	6.28E-02(N/A)	4.69E-03(N/A)	1.81E+01
Penta-CDD	1.01E-01(N/A)	6.79E-03(N/A)	2.89E+01
Hexa-CDD	2.39E-01(N/A)	1.47E-02(N/A)	6.86E+01
Hepta-CDD	4.77E-01(N/A)	2.70E-02(N/A)	1.37E+02
Octa-CDD	4.52E-01(N/A)	2.37E-02(N/A)	1.30E+02
Total PCDD	1.33E+00	7.68E-02	3.83E+02
FURANS			
2378 TCDF	ND (2.51E-03)	ND (1.98E-04)	ND (7.22E-01)
Other TCDF	3.39E-01(N/A)	2.67E-02(N/A)	9.75E+01
Penta-CDF	4.77E-01(N/A)	3.38E-02(N/A)	1.37E+02
Hexa-CDF	5.15E-01(N/A)	3.30E-02(N/A)	1.48E+02
Hepta-CDF	3.77E-01(N/A)	2.22E-02(N/A)	1.08E+02
Octa-CDF	5.03E-02(N/A)	2.72E-03(N/A)	1.44E+01
Total PCDF	1.76E+00	1.18E-01	5.05E+02

NOTE: Isomer concentrations shown are at as-measured oxygen conditions.

ND = not detected (detection limit in parentheses).
N/A = detection limits not available. For positive samples the QA samples indicate the method capability and detection limits.
ng = 1.0E-09g
ug = 1.0E-06g
ppt = parts per trillion, dry volume basis
8760 operating hours per year

TABLE D-4. SITE BLB-C DIOXIN/FURAN EMISSIONS DATA FOR RUN 1 AT THE ESP INLET . (As-measured Concentrations)

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm)	Isomer Concentration In Flue Gas (ppt)	Isomer Hourly Emissions Rate (ug/hr)
DIOXINS			
2378 TCDD	ND (N/A)	ND (N/A)	ND (N/A)
Other TCDD	8.10E-01(N/A)	6.05E-02(N/A)	2.11E+02
Penta-CDD	1.03E+00(N/A)	6.95E-02(N/A)	2.67E+02
Hexa-CDD	1.59E+00(N/A)	9.77E-02(N/A)	4.13E+02
Hepta-CDD	1.40E+00(N/A)	7.93E-02(N/A)	3.65E+02
Octa-CDD	9.35E-01(N/A)	4.89E-02(N/A)	2.43E+02
Total PCDD	5.76E+00	3.56E-01	1.50E+03
FURANS			
2378 TCDF	ND (N/A)	ND (N/A)	ND (N/A)
Other TCDF	6.17E+00(N/A)	4.85E-01(N/A)	1.60E+03
Penta-CDF	5.89E+00(N/A)	4.17E-01(N/A)	1.53E+03
Hexa-CDF	4.36E+00(N/A)	2.80E-01(N/A)	1.13E+03
Hepta-CDF	1.15E+00(N/A)	6.78E-02(N/A)	3.00E+02
Octa-CDF	1.56E-01(N/A)	8.44E-03(N/A)	4.05E+01
Total PCDF	1.77E+01	1.26E+00	4.61E+03

NOTE: Isomer concentrations shown are at as-measured oxygen conditions.

ND = not detected (detection limit in parentheses).
N/A = detection limits not available. For positive samples the QA samples indicate the method capability and detection limits.
ng = 1.0E-09g
ug = 1.0E-06g
ppt = parts per trillion, dry volume basis
8760 operating hours per year

TABLE D-5. SITE BLB-C DIOXIN/FURAN EMISSIONS DATA FOR RUN 2 AT THE ESP INLET (As-measured Concentrations)

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm)	Isomer Concentration In Flue Gas (ppt)	Isomer Hourly Emissions Rate (ug/hr)
DIOXINS			
2378 TCDD	ND (N/A)	ND (N/A)	ND (N/A)
Other TCDD	3.26E-01(N/A)	2.44E-02(N/A)	8.48E+01
Penta-CDD	4.81E-01(N/A)	3.25E-02(N/A)	1.25E+02
Hexa-CDD	1.02E+00(N/A)	6.31E-02(N/A)	2.67E+02
Hepta-CDD	7.92E-01(N/A)	4.48E-02(N/A)	2.06E+02
Octa-CDD	6.52E-01(N/A)	3.41E-02(N/A)	1.70E+02
Total PCDD	3.28E+00	1.99E-01	8.53E+02
FURANS			
2378 TCDF	ND (N/A)	ND (N/A)	ND (N/A)
Other TCDF	6.37E-01(N/A)	5.00E-02(N/A)	1.66E+02
Penta-CDF	3.73E-01(N/A)	2.64E-02(N/A)	9.70E+01
Hexa-CDF	5.12E-01(N/A)	3.29E-02(N/A)	1.33E+02
Hepta-CDF	1.86E-01(N/A)	1.10E-02(N/A)	4.85E+01
Octa-CDF	9.32E-02(N/A)	5.05E-03(N/A)	2.42E+01
Total PCDF	1.80E+00	1.25E-01	4.69E+02

NOTE: Isomer concentrations shown are at as-measured oxygen conditions.

ND = not detected (detection limit in parentheses).
N/A = detection limits not available. For positive samples the QA samples indicate the method capability and detection limits.
ng = 1.0E-09g
ug = 1.0E-06g
ppt = parts per trillion, dry volume basis
8760 operating hours per year

TABLE D-6. SITE BLB-C DIOXIN/FURAN EMISSIONS DATA FOR RUN 3 AT THE ESP INLET (As-measured Concentrations)

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm)	Isomer Concentration In Flue Gas (ppt)	Isomer Hourly Emissions Rate (ug/hr)
DIOXINS			
2378 TCDD	ND (N/A)	ND (N/A)	ND (N/A)
Other TCDD	3.86E-01(N/A)	2.88E-02(N/A)	9.39E+01
Penta-CDD	4.50E-01(N/A)	3.04E-02(N/A)	1.10E+02
Hexa-CDD	1.09E+00(N/A)	6.73E-02(N/A)	2.66E+02
Hepta-CDD	7.72E-01(N/A)	4.37E-02(N/A)	1.88E+02
Octa-CDD	6.75E-01(N/A)	3.53E-02(N/A)	1.64E+02
Total PCDD	3.38E+00	2.05E-01	8.22E+02
FURANS			
2378 TCDF	ND (N/A)	ND (N/A)	ND (N/A)
Other TCDF	7.07E-01(N/A)	5.56E-02(N/A)	1.72E+02
Penta-CDF	ND (4.18E-01)	ND (2.96E-02)	ND (1.02E+02)
Hexa-CDF	5.14E-01(N/A)	3.30E-02(N/A)	1.25E+02
Hepta-CDF	1.61E-01(N/A)	9.46E-03(N/A)	3.91E+01
Octa-CDF	ND (9.65E-02)	ND (5.23E-03)	ND (2.35E+01)
Total PCDF	1.38E+00	9.81E-02	3.37E+02

NOTE: Isomer concentrations shown are at as-measured oxygen conditions.

ND = not detected (detection limit in parentheses).
N/A = detection limits not available. For positive samples the QA samples indicate the method capability and detection limits.
ng = 1.0E-09g
ug = 1.0E-06g
ppt = parts per trillion, dry volume basis
8760 operating hours per year

APPENDIX D-2

CORRECTED TO 3 PERCENT OXYGEN RUN-SPECIFIC DIOXIN/FURAN EMISSIONS DATA

TABLE D-7. SITE BLB-C DIOXIN/FURAN EMISSIONS DATA FOR RUN 1 AT THE ESP OUTLET
(Concentrations Corrected to 3% Oxygen)

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm @ 3% oxygen)	Isomer Concentration In Flue Gas (ppt @ 3% oxygen)	Isomer Hourly Emissions Rate (ug/hr)
DIOXINS			
2378 TCDD	ND (2.39E-02)	ND (1.79E-03)	ND (2.85E+00)
Other TCDD	1.20E-01(N/A)	8.94E-03(N/A)	1.43E+01
Penta-CDD	ND (5.98E-02)	ND (4.04E-03)	ND (7.13E+00)
Hexa-CDD	1.79E-01(N/A)	1.10E-02(N/A)	2.14E+01
Hepta-CDD	2.99E-01(N/A)	1.69E-02(N/A)	3.56E+01
Octa-CDD	7.18E-01(N/A)	3.75E-02(N/A)	8.55E+01
Total PCDD	1.32E+00	7.44E-02	1.57E+02
FURANS			
2378 TCDF	ND (3.59E-02)	ND (2.82E-03)	ND (4.28E+00)
Other TCDF	2.99E-01(N/A)	2.35E-02(N/A)	3.56E+01
Penta-CDF	ND (1.20E-01)	ND (8.46E-03)	ND (1.43E+01)
Hexa-CDF	2.99E-01(N/A)	1.92E-02(N/A)	3.56E+01
Hepta-CDF	2.39E-01(N/A)	1.41E-02(N/A)	2.85E+01
Octa-CDF	1.20E-01(N/A)	6.48E-03(N/A)	1.43E+01
Total PCDF	9.57E-01	6.32E-02	1.14E+02

NOTE: Isomer concentrations shown are corrected to 3% oxygen.

ND = not detected (detection limit in parentheses).
N/A = detection limits not available. For positive samples the QA samples indicate the method capability and detection limits.
ng = 1.0E-09g
ug = 1.0E-06g
ppt = parts per trillion, dry volume basis
8760 operating hours per year

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TABLE D-8. SITE BLB-C DIOXIN/FURAN EMISSIONS DATA FOR RUN 2 AT THE ESP OUTLET (Concentrations Corrected to 3% Oxygen)

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm @ 3% oxygen)	Isomer Concentration In Flue Gas (ppt @ 3% oxygen)	Isomer Hourly Emissions Rate (ug/hr)
DIOXINS			
2378 TCDD	ND (3.90E-03)	ND (2.92E-04)	ND (1.34E+00)
Other TCDD	1.07E-01(N/A)	8.02E-03(N/A)	3.69E+01
Penta-CDD	2.15E-01(N/A)	1.45E-02(N/A)	7.37E+01
Hexa-CDD	4.10E-01(N/A)	2.52E-02(N/A)	1.41E+02
Hepta-CDD	1.19E+00(N/A)	6.74E-02(N/A)	4.09E+02
Octa-CDD	2.34E+00(N/A)	1.23E-01(N/A)	8.04E+02
Total PCDD	4.27E+00	2.38E-01	1.46E+03
FURANS			
2378 TCDF	1.56E-02(N/A)	1.23E-03(N/A)	5.36E+00
Other TCDF	2.58E-01(N/A)	2.03E-02(N/A)	8.85E+01
Penta-CDF	2.15E-01(N/A)	1.52E-02(N/A)	7.37E+01
Hexa-CDF	2.25E-01(N/A)	1.44E-02(N/A)	7.71E+01
Hepta-CDF	3.32E-01(N/A)	1.95E-02(N/A)	1.14E+02
Octa-CDF	3.90E-02(N/A)	2.12E-03(N/A)	1.34E+01
Total PCDF	1.08E+00	7.27E-02	3.72E+02

NOTE: Isomer concentrations shown are corrected to 3% oxygen.

ND = not detected (detection limit in parentheses).
N/A = detection limits not available. For positive samples the QA samples indicate the method capability and detection limits.
ng = 1.0E-09g
ug = 1.0E-06g
ppt = parts per trillion, dry volume basis
8760 operating hours per year

TABLE D-9. SITE BLB-C DIOXIN/FURAN EMISSIONS DATA FOR RUN 3 AT THE ESP OUTLET (Concentrations Corrected to 3% Oxygen)

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm @ 3% oxygen)	Isomer Concentration In Flue Gas (ppt @ 3% oxygen)	Isomer Hourly Emissions Rate (ug/hr)
DIOXINS			
2378 TCDD	ND (6.11E-03)	ND (4.57E-04)	ND (7.22E-01)
Other TCDD	1.53E-01(N/A)	1.14E-02(N/A)	1.81E+01
Penta-CDD	2.44E-01(N/A)	1.65E-02(N/A)	2.89E+01
Hexa-CDD	5.81E-01(N/A)	3.57E-02(N/A)	5.86E+01
Hepta-CDD	1.16E+00(N/A)	6.57E-02(N/A)	1.37E+02
Octa-CDD	1.10E+00(N/A)	5.75E-02(N/A)	1.30E+02
Total PCDD	3.24E+00	1.87E-01	3.83E+02
FURANS			
2378 TCDF	ND (6.11E-03)	ND (4.80E-04)	ND (7.22E-01)
Other TCDF	8.25E-01(N/A)	6.49E-02(N/A)	9.75E+01
Penta-CDF	1.16E+00(N/A)	8.22E-02(N/A)	1.37E+02
Hexa-CDF	1.25E+00(N/A)	8.04E-02(N/A)	1.48E+02
Hepta-CDF	9.17E-01(N/A)	5.39E-02(N/A)	1.08E+02
Octa-CDF	1.22E-01(N/A)	6.62E-03(N/A)	1.44E+01
Total PCDF	4.28E+00	2.88E-01	5.05E+02

NOTE: Isomer concentrations shown are corrected to 3% oxygen.

ND = not detected (detection limit in parentheses).
N/A = detection limits not available. For positive samples the QA samples indicate the method capability and detection limits.
ng = 1.0E-09g
ug = 1.0E-06g
ppt = parts per trillion, dry volume basis
8760 operating hours per year

TABLE D-10. SITE BLB-C DIOXIN/FURAN EMISSIONS DATA FOR RUN 1 AT THE ESP INLET
(Concentrations Corrected to 3% Oxygen)

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm @ 3% oxygen)	Isomer Concentration In Flue Gas (ppt @ 3% oxygen)	Isomer Hourly Emissions Rate (ug/hr)
DIOXINS			
2378 TCDD	ND (N/A)	ND (N/A)	ND (N/A)
Other TCDD	1.76E+00(N/A)	1.31E-01(N/A)	2.11E+02
Penta-CDD	2.23E+00(N/A)	1.51E-01(N/A)	2.67E+02
Hexa-CDD	3.45E+00(N/A)	2.12E-01(N/A)	4.13E+02
Hepta-CDD	3.04E+00(N/A)	1.72E-01(N/A)	3.65E+02
Octa-CDD	2.03E+00(N/A)	1.06E-01(N/A)	2.43E+02
Total PCDD	1.25E+01	7.72E-01	1.50E+03
FURANS			
2378 TCDF	ND (N/A)	ND (N/A)	ND (N/A)
Other TCDF	1.34E+01(N/A)	1.05E+00(N/A)	1.60E+03
Penta-CDF	1.28E+01(N/A)	9.03E-01(N/A)	1.53E+03
Hexa-CDF	9.46E+00(N/A)	6.07E-01(N/A)	1.13E+03
Hepta-CDF	2.50E+00(N/A)	1.47E-01(N/A)	3.00E+02
Octa-CDF	3.38E-01(N/A)	1.83E-02(N/A)	4.05E+01
Total PCDF	3.84E+01	2.73E+00	4.61E+03

NOTE: Isomer concentrations shown are corrected to 3% oxygen.

ND = not detected (detection limit in parentheses).
N/A = detection limits not available. For positive samples the QA samples indicate the method capability and detection limits.
ng = 1.0E-09g
ug = 1.0E-06g
ppt = parts per trillion, dry volume basis
8760 operating hours per year

TABLE D-11. SITE BLB-C DIOXIN/FURAN EMISSIONS DATA FOR RUN 2 AT THE ESP INLET (Concentrations Corrected to 3% Oxygen)

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm @ 3% oxygen)	Isomer Concentration In Flue Gas (ppt @ 3% oxygen)	Isomer Hourly Emissions Rate (ug/hr)
DIOXINS			
2378 TCDD	ND (N/A)	ND (N/A)	ND (N/A)
Other TCDD	7.62E-01(N/A)	5.69E-02(N/A)	8.48E+01
Penta-CDD	1.13E+00(N/A)	7.60E-02(N/A)	1.25E+02
Hexa-CDD	2.40E+00(N/A)	1.47E-01(N/A)	2.67E+02
Hepta-CDD	1.85E+00(N/A)	1.05E-01(N/A)	2.06E+02
Octa-CDD	1.52E+00(N/A)	7.97E-02(N/A)	1.70E+02
Total PCDD	7.66E+00	4.65E-01	8.53E+02
FURANS			
2378 TCDF	ND (N/A)	ND (N/A)	ND (N/A)
Other TCDF	1.49E+00(N/A)	1.17E-01(N/A)	1.66E+02
Penta-CDF	8.71E-01(N/A)	6.16E-02(N/A)	9.70E+01
Hexa-CDF	1.20E+00(N/A)	7.68E-02(N/A)	1.33E+02
Hepta-CDF	4.36E-01(N/A)	2.56E-02(N/A)	4.85E+01
Octa-CDF	2.18E-01(N/A)	1.18E-02(N/A)	2.42E+01
Total PCDF	4.21E+00	2.93E-01	4.69E+02

NOTE: Isomer concentrations shown are corrected to 3% oxygen.

ND = not detected (detection limit in parentheses).
N/A = detection limits not available. For positive samples the QA samples indicate the method capability and detection limits.
ng = 1.0E-09g
ug = 1.0E-06g
ppt = parts per trillion, dry volume basis
8760 operating hours per year

TABLE D-12. SITE BLB-C DIOXIN/FURAN EMISSIONS DATA FOR RUN 3 AT THE ESP INLET (Concentrations Corrected to 3% Oxygen)

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm @ 3% oxygen)	Isomer Concentration In Flue Gas (ppt @ 3% oxygen)	Isomer Hourly Emissions Rate (ug/hr)
DIOXINS			
2378 TCDD	ND (N/A)	ND (N/A)	ND (N/A)
Other TCDD	7.80E-01(N/A)	5.83E-02(N/A)	9.39E+01
Penta-CDD	9.10E-01(N/A)	6.15E-02(N/A)	1.10E+02
Hexa-CDD	2.21E+00(N/A)	1.36E-01(N/A)	2.66E+02
Hepta-CDD	1.56E+00(N/A)	8.83E-02(N/A)	1.88E+02
Octa-CDD	1.37E+00(N/A)	7.14E-02(N/A)	1.64E+02
Total PCDD	6.83E+00	4.16E-01	8.22E+02
FURANS			
2378 TCDF	ND (N/A)	ND (N/A)	ND (N/A)
Other TCDF	1.43E+00(N/A)	1.12E-01(N/A)	1.72E+02
Penta-CDF	ND (8.45E-01)	ND (5.98E-02)	ND (1.02E+02)
Hexa-CDF	1.04E+00(N/A)	6.67E-02(N/A)	1.25E+02
Hepta-CDF	3.25E-01(N/A)	1.91E-02(N/A)	3.91E+01
Octa-CDF	ND (1.95E-01)	ND (1.06E-02)	ND (2.35E+01)
Total PCDF	2.80E+00	1.98E-01	3.37E+02

NOTE: Isomer concentrations shown are corrected to 3% oxygen.

ND = not detected (detection limit in parentheses).
N/A = detection limits not available. For positive samples the QA samples indicate the method capability and detection limits.
ng = 1.0E-09g
ug = 1.0E-06g
ppt = parts per trillion, dry volume basis
8760 operating hours per year

APPENDIX E

RUN-SPECIFIC RISK MODELING INPUT DATA

TABLE E-1. SITE BLB-C RISK MODELING PARAMETERS FOR RUN 1

Latitude = 47 15 58
Longitude = 122 25 29
Stack Height (From Grade Level) = 77.1 m
Stack Diameter (ID) = 3.35 m
Flue Gas Flow Rate (Dry Standard) = 4964 dscmm
Flue Gas Exit Temperature = 418 K
Flue Gas Exit Velocity (Actual) = 988.1 mpm

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm)	Isomer Hourly Emissions Rate (ug/hr)	Relative Potency Factor	2,3,7,8 - TCDD Equivalent Emissions (mg/yr)
2378 TCDD	ND (9.57E-03)	ND (2.85E+00)	1.000	ND (2.50E+01)
Other TCDD	4.78E-02	1.43E+01	.010	1.25E+00
2378 TCDF	ND (1.44E-02)	ND (4.28E+00)	.100	ND (3.75E+00)
Other TCDF	1.20E-01	3.56E+01	.001	3.12E-01
Penta-CDD	ND (2.39E-02)	ND (7.13E+00)	.500	ND (3.12E+01)
Penta-CDF	ND (4.78E-02)	ND (1.43E+01)	.100	ND (1.25E+01)
Hexa-CDD	7.18E-02	2.14E+01	.040	7.49E+00
Hexa-CDF	1.20E-01	3.56E+01	.010	3.12E+00
Hepta-CDD	1.20E-01	3.56E+01	.001	3.12E-01
Hepta-CDF	9.57E-02	2.85E+01	.001	2.50E-01
Octa-CDD	2.87E-01	8.55E+01	.000	.00E+00
Octa-CDF	4.78E-02	1.43E+01	.000	.00E+00
Net 2378 TCDD Equivalent Atmospheric Loading				1.27E+01

ND = not detected (detection limit in parentheses).
N/A = detection limit not available
ng = 1.0E-09g
ug = 1.0E-06g
mg = 1.0E-03g
Standard conditions: 293 K (20 C) temperature and 1 atmosphere pressure.
8760 operating hours per year

TABLE E-2. SITE BLB-C RISK MODELING PARAMETERS FOR RUN 2

Latitude = 47 15 58
Longitude = 122 25 29
Stack Height (From Grade Level) = 77.1 m
Stack Diameter (ID) = 3.35 m
Flue Gas Flow Rate (Dry Standard) = 4937 dscmm
Flue Gas Exit Temperature = 419 K
Flue Gas Exit Velocity (Actual) = 986.6 mpm

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm)	Isomer Hourly Emissions Rate (ug/hr)	Relative Potency Factor	2,3,7,8 - TCDD Equivalent Emissions (mg/yr)
2378 TCDD	ND (4.52E-03)	ND (1.34E+00)	1.000	ND (1.17E+01)
Other TCDD	1.24E-01	3.69E+01	.010	3.23E+00
2378 TCDF	1.81E-02	5.36E+00	.100	4.70E+00
Other TCDF	2.99E-01	8.85E+01	.001	7.75E-01
Penta-CDD	2.49E-01	7.37E+01	.500	3.23E+02
Penta-CDF	2.49E-01	7.37E+01	.100	6.46E+01
Hexa-CDD	4.75E-01	1.41E+02	.040	4.93E+01
Hexa-CDF	2.60E-01	7.71E+01	.010	6.75E+00
Hepta-CDD	1.38E+00	4.09E+02	.001	3.58E+00
Hepta-CDF	3.85E-01	1.14E+02	.001	9.98E-01
Octa-CDD	2.71E+00	8.04E+02	.000	.00E+00
Octa-CDF	4.52E-02	1.34E+01	.000	.00E+00
Net 2378 TCDD Equivalent Atmospheric Loading				4.57E+02

ND = not detected (detection limit in parentheses).
N/A = detection limit not available
ng = 1.0E-09g
ug = 1.0E-06g
mg = 1.0E-03g
Standard conditions: 293 K (20 C) temperature and 1 atmosphere pressure.
8760 operating hours per year

TABLE E-3. SITE BLB-C RISK MODELING PARAMETERS FOR RUN 3

Latitude = 47 15 58
Longitude = 122 25 29
Stack Height (From Grade Level) = 77.1 m
Stack Diameter (ID) = 3.35 m
Flue Gas Flow Rate (Dry Standard) = 4790 dscmm
Flue Gas Exit Temperature = 420 K
Flue Gas Exit Velocity (Actual) = 957.5 mpm

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm)	Isomer Hourly Emissions Rate (ug/hr)	Relative Potency Factor	2,3,7,8 - TCDD Equivalent Emissions (mg/yr)
2378 TCDD	ND (2.51E-03)	ND (7.22E-01)	1.000	ND (6.33E+00)
Other TCDD	6.28E-02	1.81E+01	.010	1.58E+00
2378 TCDF	ND (2.51E-03)	ND (7.22E-01)	.100	ND (6.33E-01)
Other TCDF	3.39E-01	9.75E+01	.001	8.54E-01
Penta-CDD	1.01E-01	2.89E+01	.500	1.27E+02
Penta-CDF	4.77E-01	1.37E+02	.100	1.20E+02
Hexa-CDD	2.39E-01	6.86E+01	.040	2.40E+01
Hexa-CDF	5.15E-01	1.48E+02	.010	1.30E+01
Hepta-CDD	4.77E-01	1.37E+02	.001	1.20E+00
Hepta-CDF	3.77E-01	1.08E+02	.001	9.49E-01
Octa-CDD	4.52E-01	1.30E+02	.000	.00E+00
Octa-CDF	5.03E-02	1.44E+01	.000	.00E+00
Net 2378 TCDD Equivalent Atmospheric Loading				2.88E+02

ND = not detected (detection limit in parentheses).
N/A = detection limit not available
ng = 1.0E-09g
ug = 1.0E-06g
mg = 1.0E-03g
Standard conditions: 293 K (20 C) temperature and 1 atmosphere pressure.
8760 operating hours per year

APPENDIX F
RUN-SPECIFIC HOMOLOGUE DISTRIBUTIONS

TABLE F-1. SITE BLB-C HOMOLOGUE DISTRIBUTION AT THE OUTLET

HOMOLOGUES	HOMOLOGUE FRACTION					
	RUN 01		RUN 02		RUN 03	
DIOXINS	MASS	MOLE	MASS	MOLE	MASS	MOLE
2378 TCDD	0	0	0	0	0	0
Other TCDD	0.0909	0.1201	0.0252	0.0338	0.0472	0.0611
Penta-CDD	0	0	0.0503	0.0611	0.0755	0.0884
Hexa-CDD	0.1364	0.1483	0.0961	0.1061	0.1792	0.1911
Hepta-CDD	0.2273	0.2274	0.2792	0.2836	0.3585	0.3516
Octa-CDD	0.5455	0.5042	0.5492	0.5155	0.3396	0.3078
FURANS						
2378 TCDF	0	0	0.0144	0.0169	0	0
Other TCDF	0.3125	0.3717	0.2378	0.2786	0.1929	0.2253
Penta-CDF	0	0	0.1982	0.2089	0.2714	0.2853
Hexa-CDF	0.3125	0.3033	0.2072	0.1981	0.2929	0.2791
Hepta-CDF	0.25	0.2225	0.3063	0.2684	0.2143	0.1873
Octa-CDF	0.125	0.1025	0.036	0.0291	0.0286	0.023

APPENDIX G
COMPOUND-SPECIFIC PRECURSOR RESULTS

TABLE G-1. COMPOUND-SPECIFIC DIOXIN PRECURSOR DATA FOR SITE BLB-C FEED SAMPLES

Precursor Compounds	Precursor Concentration, ug/g (ppm)		
	Black Liquor Feed Samples		
	Run 1	Run 2	Run 3
Base Neutrals Fraction			
Chlorinated Benzenes:			
Dichlorobenzenes	ND	ND	ND
Trichlorobenzenes	ND	ND	ND
Tetrachlorobenzenes	ND	ND	ND
Pentachlorobenzenes	ND	ND	ND
Hexachlorobenzenes	ND	ND	ND
Total Chlorinated Benzenes	ND	ND	ND
Chlorinated Biphenyls:			
Chlorobiphenyls	ND	ND	ND
Dichlorobiphenyls	ND	ND	ND
Trichlorobiphenyls	ND	ND	ND
Tetrachlorobiphenyls	ND	ND	ND
Pentachlorobiphenyls	ND	ND	ND
Hexachlorobiphenyls	ND	ND	ND
Heptachlorobiphenyls	ND	ND	ND
Octachlorobiphenyls	ND	ND	ND
Nonachlorobiphenyls	ND	ND	ND
Decachlorobiphenyls	ND	ND	ND
Total Chlorinated Biphenyls	ND	ND	ND
Acids Fraction			
Chlorinated Phenols:			
Dichlorophenols	ND	ND	ND
Trichlorophenols	ND	ND	ND
Tetrachlorophenols	ND	ND	ND
Pentachlorophenols	0	trace	0.01
Total Chlorinated Phenols	0	trace	0.01

APPENDIX H
TESTING PERSONNEL

TABLE H-1. TESTING PERSONNEL

Name	Affiliation
Larry E. Keller	Radian Corporation
Bob Jongleux	Radian Corporation
Jim McReynolds	Radian Corporation
Lee Garcia	Radian Corporation
Gary Henry	Radian Corporation
Dave Savia	Radian Corporation
Mike Hartman	Radian Corporation
Deborah Benson	Radian Corporation
Carol Jamgochian	Radian Corporation

APPENDIX I
ERROR ANALYSIS: CONTROL DEVICE EFFICIENCY CALCULATIONS

Objective: Given the analytical uncertainty of the dioxin/furan analyses (± 50% accuracy), estimate the uncertainty of the control device efficiency calculations.

Let: $C_{out,meas}$ = the measured concentration of a given dioxin/furan homologue at the outlet location.

$C_{in,meas}$ = the measured concentration of a given dioxin/furan homologue at the inlet location.

$C_{out,max}$ = the maximum possible concentration of the dioxin/furan homologue given the measured value $C_{out,meas}$.

$C_{out,min}$ = the minimum possible concentration of the dioxin/furan homologue given the measured value $C_{out,meas}$.

$C_{in,max}$ = the maximum possible concentration of the dioxin/furan homologue, given the measured value $C_{in,meas}$.

$C_{in,min}$ = the minimum possible concentration of the dioxin/furan homologue, given the measured value $C_{in,meas}$.

E = the removal efficiency of the control device

Assuming ± 50 percent analytical accuracy:

$$C_{min} = C_{meas} - 0.5\ C_{meas} = 0.5\ C_{meas}$$

$$C_{max} = C_{meas} + 0.5\ C_{meas} = 1.5\ C_{meas}$$

Note that: $$E_{max} = \frac{C_{in,max} - C_{out,min}}{C_{in,max}} = 1 - \frac{C_{out,min}}{C_{in,max}}$$

$$E_{max} = 1 - \frac{0.5\ C_{out,meas}}{1.5\ C_{in,meas}} = 1 - {}^{1}/_{3}\ (1 - E_{meas})$$

$$= {}^{2}/_{3} + {}^{1}/_{3}\ E_{meas}$$

and:

$$E_{min} = \frac{C_{in,min} - C_{out,max}}{C_{in,min}} = 1 - \frac{C_{out,max}}{C_{in,min}}$$

$$= 1 - \frac{1.5\ C_{out,meas}}{0.5\ C_{in,meas}}$$

$$= 1 - 3\ (1 - E_{meas})$$

$$E_{min} = 3\ E_{meas} - 2$$

Now, $E_{min} > 0$ positive control (i.e., emissions reduction across the control device)

$$(3E_{meas} - 2) > 0$$

$$E_{meas} > {}^{2}/_{3}$$

Therefore, if E_{meas} is larger than 66.7 percent, the true removal efficiency can safely be assumed to be greater than zero.

And, $E_{max} < 0$ negative control (i.e., emissions increase across the control device)

$${}^{2}/_{3} + {}^{1}/_{3}\ E_{meas} < 0$$

$$E_{meas} < -2$$

Therefore, if E_{meas} is less than -200 percent, the true efficiency can safely be assumed to be less than zero.

To summarize:

$E_{meas} > 66.7$ percent	positive control
$-200 < E_{meas} < 66.7$ percent	no definitive conclusions can be drawn
$E_{meas} < 200$ percent	no negative control

TABLE I.1 VALUES OF E_{max} and E_{min} FOR VARIOUS MEASURED CONTROL EFFICIENCIES

Control Device Efficiency (%)		
E_{meas}	E_{max}	E_{min}
100	100	100
95	98.3	85
90	96.7	70
85	95.0	55
80	93.4	40
75	91.7	25
50	83.4	-50
25	75.0	-125
0	66.7	-200
-25	58.4	-275
-50	50.0	-350
-100	33.4	-500
-200	0	-800

$$E_{max} = (200 + E_{meas})/3$$

$$E_{min} = 3E_{meas} - 200$$

APPENDIX J
SAMPLE SHIPMENT LETTERS

April 26,1985

U. S. EPA ECC Toxicant Analysis Center
Building 1105
Bay St. Louis, MS 39529

Attention: Danny McDaniel

Subject: Tier 4 - Analysis Instructions
Site 08
Site 08

Dear Sir:

The objective of this letter is to clarify instructions and priorities for individual samples from specific Tier 4 combustion sites. This instruction letter is No. 9 and pertains to EPA Site No. 08 at Tacoma, WA.

The Episode No. is 2634, and SCC numbers assigned to this site were numbers DQ000800 through DQ000899.

SCC numbers DQ000800 through DQ000805 have been assigned to Troika for internal QA/QC purposes. SCC numbers DQ000806 through DQ000826 have been assigned to samples included in this shipment and number DQ000827 has been assigned to a sample being archived at Radian. All remaining SCC numbers are unused.

The sample shipment for EPA Site No. 08 consists of 4 boxes containing 64 samples in 67 containers. (Note-The Modified Method 5 samples are comprised of 6 components as listed below. Three (3) MM5 sample runs have more than one container per component as indicated by asterisk.) The sample shipment was shipped air freight on April 26 ,1985 by Federal Express under Airbill(s) No.289783395 and No.544545665.

Instructions for extraction and analysis follow.

Priority #1 samples include the MM5 sample train components, the MM5 field blanks, the MM5 proof blank, the solvent blanks, and the electrostatic precipitator catch samples. These samples require immediate extraction and analysis, as follows:

MM5 TRAINS

Radian Run #08-MM5-EI-01
(Total of 6 train components)

SCC #	Component	Fraction
DQ000806	1	Filter
DQ000806	2*(2 containers)	Probe Rinse (++)
DQ000806	3	Back Half/Coil Rinse
DQ000806	4	Condensate
DQ000806	5	Impinger Solution
DQ000806	6	XAD Module

(++ The probe rinse consists of water, acetone and methylene chloride.)

Radian Run # 08-MM5-EI-02
(Total of 6 train components)

SCC #	Components	Fraction
DQ000811	1	Filter
DQ000811	2	Probe Rinse (++)
DQ000811	3	Back Half/Coil Rinse
DQ000811	4	Condensate
DQ000811	5	Impinger Solution
DQ000811	6	XAD Module

(++) The probe rinse consists of water, acetone, and methylene chloride.

Radian Run # 08-MM5-EI-03
(Total of 6 train components)

SCC #	Components	Fraction
DQ000822	1	Filter
DQ000822	2*(2 containers)	Probe Rinse (++)
DQ000822	3	Back Half/Coil Rinse
DQ000822	4	Condensate
DQ000822	5	Impinger Solution
DQ000822	6	XAD Module

(++) The probe rinse consists of water, acetone, and methylene chloride.

Radian Run # 08-MM5-EO-01
(Total of 6 train components)

SCC #	Components	Fraction
DQ000807	1	Filter
DQ000807	2	Probe Rinse (++)
DQ000807	3	Back Half/Coil Rinse
DQ000807	4	Condensate
DQ000807	5	Impinger Solution
DQ000807	6	XAD Module

(++) The probe rinse consists of water, acetone, and methylene chloride.

Radian Run # 08-MM5-EO-02
(Total of 6 train components)

SCC #	Components	Fraction
DQ000812	1	Filter
DQ000812	2	Probe Rinse (++)
DQ000812	3	Back Half/Coil Rinse
DQ000812	4	Condensate
DQ000812	5	Impinger Solution
DQ000812	6	XAD Module

(++) The probe rinse consists of water, acetone and methylene chloride.

Radian Run # 08-MM5-EO-03
(Total of 6 train components)

SCC #	Components	Fraction
DQ000821	1	Filter
DQ000821	2*(2 containers)	Probe Rinse (++)
DQ000821	3	Back Half/Coil Rinse
DQ000821	4	Condensate
DQ000821	5	Impinger Solution
DQ000821	6	XAD Module

(++) The probe rinse consists of water, acetone and methylene chloride.

MM5 FIELD BLANK TRAINS

Run # 08-MM5-EI-BL
(Total of 6 train components)

SCC #	Components	Fraction
DQ000815	1	Filter
DQ000815	2	Probe Rinse (++)
DQ000815	3	Back Half/Coil Rinse
DQ000815	4	Condensate
DQ000815	5	Impinger Solution
DQ000815	6	XAD Module

(++) The probe rinse consists of water, acetone, and methylene chloride.

Radian Run # 08-MM5-EO-BL
(Total of 6 train components)

SCC #	Components	Fraction
DQ000816	1	Filter
DQ000816	2	Probe Rinse (++)
DQ000816	3	Back Half/Coil Rinse
DQ000816	4	Condensate
DQ000816	5	Impinger Solution
DQ000816	6	XAD Module

(++) The probe rinse consists of water, acetone and methylene chloride.

MM5 PROOF BLANK

The MM5 proof blank is recovered unused field sampling glassware tra components. The proof train consists of the following fractions:

SCC #	CONTAINER	FRACTION
DQ000810	1	Filter
DQ000810	2	Probe Rinse
DQ000810	3	Methylene Chloride Rinse of probe, filter housing, Coil, Sorbent Module, and Impingers

AMBIENT TRAIN

SCC #	CONTAINER	SAMPLE CODE	DESCRIPTION
DQ000825	1	08-AMB-A-PR	PROBE RINSE
DQ000825	2	08-AMB-A-SM	XAD MODULE

REAGENT BLANKS

SCC #	RADIAN SAMPLE CODE	SAMPLE TYPE
DQ000819	08-FBL	Acetone (Lot #851502)
DQ000817	08-FBL	HPLC Water (Lot #851325)
DQ000818	08-FBL	HPLC Water (Lot #745854)
DQ000820	08-FBL	Methylene Chloride (Lot #740854)

ELECTROSTATIC PRECIPITATOR CATCH

SCC #	RADIAN SAMPLE CODE	SAMPLE TYPE
DQ000809	08-EPC-01	ESP Catch, Run # 1
DQ000814	08-EPC-02	ESP Catch, Run # 2
DQ000824	08-EPC-03	ESP Catch, Run # 3

2. The Priority # 2 samples include three strong black liquor samples, one fuel oil sample ,and a ambient air sample train. These samples should be held by for analysis by TROIKA pending the results of Priority 1 analysis.

STRONG BLACK LIQUOR SAMPLES

SCC #	RADIAN SAMPLE CODE	SAMPLE TYPE
DQ000808	08-SBL-01	Strong Black Liquor, Run 1
DQ000813	08-SBL-02	Strong Black Liquor, Run 2
DQ000823	08-SBL-03	Strong Black Liquor, Run 3

FUEL OIL SAMPLE

SCC #	RADIAN SAMPLE CODE	SAMPLE TYPE
DQ000826	08-FO-A	Fuel Oil, Run 3

AMBIENT SAMPLE TRAIN

SCC #	RADIAN SAMPLE CODE	SAMPLE TYPE
DQ000825	08-AMB-A-PR	Probe Rinse
DQ000825	08-AMB-A-SM	XAD Module

3. The soil sample is the only Priority #3 sample. It will be held by Radian for analysis by Troika pending the results of Priority #1 and Priority #2 sample analyses.

SCC #		Sample
DQ000827	# 08-S	Soils

If there are any questions concerning this sample shipment. Please contact either Larry Keller or Bob Jongleux at Radian Corporation (919) 541-9100 or (919) 481-0212.

Sincerely,

Robert Jongleux
TEST TEAM LEADER

cc.E. Hanks-EPA/AMTB
A. Miles-Radian
Radian Field File RTP/PP